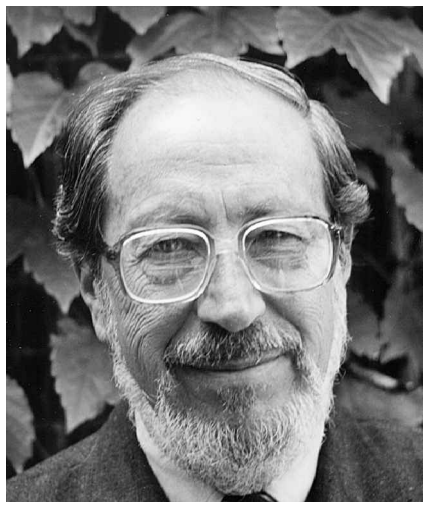
From the Founding Editor



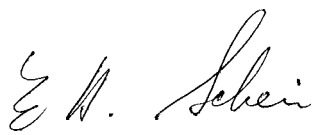
The most exciting part of this new venture for me is the freedom to innovate. We have a great editorial team, a supportive and creative board, and, most importantly, a great audience of academics, consultants, and practitioners. I would also like to announce our good fortune in having been able to hire Jane Gebhart, an experienced editor, to take over the duties of Managing Editor while Karen Ayas and I focus more on developing the content of the future issues.

My goal, to restate it, is to contribute through this journal to the creation, dissemination, and utilization of knowledge and skill in the broad areas of learning and change. And by knowledge I mean to include know-how and skill. In fact, one of the most challenging aspects of this kind of one-way communication is how to involve readers in it. As John Seely Brown put it at our board meeting, "We must learn from playwrights and artists who also have the problem of involving the audience in a one-way communication."

I also think it is important to gain historical perspective—to realize that what we are saying today is not really the first time it is being said. This point is especially relevant for this issue with Jay Forrester's classic article on how we might create organizations. I met Jay in 1956, the year we both joined the Sloan School, because his office was right next to Doug McGregor's, my mentor, and Doug Brown's—one of the seminal thinkers in the field of labor relations. I mention these neighbors because I have no doubt but that the many hours of conversation I observed among these three must have influenced Jay's outlook on organizations, an outlook that he so brilliantly articulated in the classic 1965 paper we reprint in this issue.

Jay and his students, several of whom have articles in this issue, represent what has come to be called the "socio-technical" view of organizations, a term first invented by the researcher clinicians at the Tavistock Institute in the UK in the 1940s. No serious student of human systems can think clearly about organizational process without considering the technological basis on which the organization's primary task is built. Though Jay does not bring that point out explicitly, his own background as an engineer clearly informs his insights about organizations. Jay came to MIT in the late 1940s as an inventor (computer core memory) and electrical engineer in the MIT Labs. Ken Olsen, the founder of Digital Equipment Corporation, credits the climate set by Jay and others for his own early development as an engineer and entrepreneur.

Incidentally, the cover is a photograph from another of Jay's colleagues, Professor Emeritus Arthur Von Hippel. We thought that this photo captured visually how an intellectual tradition radiates out from a center and eventually will break out of its bounds into new and unknown territories.



Ed Schein

It was with great anticipation and subsequent sense of pride that I received and slowly feasted on the unique, real gourmet fare that *Reflections* produced in its first issue. As a student of Karl Popper's History of Science and development of ideas, I am especially delighted to find Kurt Lewin's paper on Social Fields leading the issue. What a timely reminder that wisdom is ageless.

Commentaries are a very welcome innovation. They both enliven and greatly contribute to individual scholarly contributions. While I cannot have a conversation with an author of the paper I am reading, this way I do get a higher feel of involvement, especially where those who provided their views brought a very different perspective to the topic than author's.

It is befitting a journal with the title "reflections" to encourage slow and deliberate reading. That is not my usual way of approaching academic publications or trade magazines.

For all the above, most valuable and also moving for me has been to hear a sentence I reread from Russell Ackoff's paper today (Oct. 4, 1999) echoed almost verbatim by a 15-year-old girl in an evening class I attend. She simply and matter-of-factly stated in her interpretation of the story we were studying that, "We learn only from our mistakes, being right does not teach you anything." So, this wisdom is available and within us all! How often we dismiss it!

I remain, with you, the editors and contributors, committed to share our age-old learnings and celebrate them wherever and from whoever they may come. Perhaps we should invite observations from our children and grandchildren for the next issue. Are we brave enough?

With respect,
Dr. Lilly Evans

Don Michael's article (volume 1, issue 2) is a treasure. Thank you for placing it before us. The corner that he helps us turn with his choice of language—from "changing" to "influencing or affecting," from a widely held belief in the instinct and drive to control to the "aspiration to control" (we could hold a different aspiration, he suggests), from the leader's pretense of a solid grasp on reality, to the leader's role in encouraging a collective curiosity about a dynamic and unfolding world—all this represents a fundamental shift in thinking, a change of mindset that could help us as leaders, managers, and individuals engage in the world around us in a much more productive and powerful way. He invites us into that mindset, giving us a chance to sit with these ideas, to consider an alternative to our fascination with control. Even as hard as it sometimes is to give up control in favor of courage, curiosity, and caring, Michael's case and his counsel are compelling.

Yet, we already live by the truth of what Michael suggests in certain parts of our lives: in loving our children, in growing gardens, in sailing, in skiing deep powder snow on steep slopes, in farming, in dancing, in writing poetry, in composing music. These are all arenas of dynamic movement in which we participate but by no means have control, nor aspire to it. The article reminds me that we have walled off a larger and larger part of our world, particularly the world of work, from our own understanding of how to work and participate in a dynamic that is emergent. Perhaps the Michael article can help us reclaim that understanding and apply it to a greater and greater portion of our lives and our world.

Cordially,
Judy Sorum Brown

EDITORIAL

In This Issue

Edgar H. Schein and Karen Ayas

Welcome to issue 3 of *Reflections*. Several of the articles in this issue revolve around a theme based on an intellectual tradition that was started 50 years ago by Jay Forrester. It is with great pleasure that we showcase Forrester and some of his students. We also invite you to meet Gary Hamel, one of the world's leading thinkers in the field of strategy and learning.

Classics

In the human arena certain insights need to be stated over and over again. It is fun and important to bring back the classics. Forrester's 1965 article on organizations is as relevant today as it was then. Comments from Daniel Kim, a seasoned consultant and a former student in the field of system dynamics, and Georgianna Bishop, a practicing manager in a public institution, attest to this.

Features

We begin with John Sterman's article displaying a set of concepts and a modeling tool that informs our understanding of human cognition, and especially its limitations. Sterman, more than anyone else in this field, has shown how system dynamics—the research methodology and simulation—can be used to test important hypotheses about the long- and short-range consequences of how managers think and make decisions. This is an academic article that needs to be read slowly and carefully. While Ray Stata, the founder and president of Analog Devices, seems to be more optimistic about our capacity to learn and improve than Sterman, Richard Karash, a consultant experimenting with these tools for a while, expresses deeper concerns about Sterman's approach to learning and argues the impossibility of results with certainty.

We follow with another of Forrester's protégés, Peter Senge, who brings his organizational learning point of view and systemic approach to the field of education in a talk delivered in 1998. Readers will find his view of the learning process enlightening and will have to reflect on how much or how little of this kind of learning actually occurs in our educational system. An educator and national administrator of a national school reform program, Edward Joyner, comments on Senge's assumptions about the learning process in schools. Jay Forrester brings real-life examples of the impact of system dynamics pioneered in many schools.

The application of systems thinking to the practical problems of organizations trying to work together is well illustrated by Jennifer Kemeny (another student of Forrester) and her colleague at Innovation Associates, Joel Yanowitz. Drawing from their consulting experience, Kemeny and Yanowitz reveal the key obstacles to cross-organizational relationships and offer a roadmap for action. Managers will find this article on strategic alliances of great interest as attested to by Linda Pierce from Shell Oil Company and Anil Paranjpe from British Telecom.

We close this section with a conversation with Gary Hamel who is not shy about telling us what is missing in current concepts of strategic thinking. This is a most stimulating and enlightening interview conducted by Otto Scharmer. It certainly deserves a careful look, as it is an invitation to rethink strategy and the underlying mental models.

We continue to explore new terrain in this issue. Two of our readers, Judy Brown (a consultant) and Surinder Deol (from World Bank), have contributed poems. Remember, we need to hear your voice to keep the journal lively. We close with book reviews and announcements. In this issue we bring you two reviews of books that have recently been published.

Once again, please write or e-mail us your suggestions and recommendations. Let us know what you would like to see. Send all mail electronically to jane@sol-ne.org or to Editor, *Reflections: The SoL Journal*, 222 Third Street, Suite 2323, Cambridge, MA 02142.

Contributors

Georgianna Bishop is responsible for the training, career development, and organizational development activities for the New England Office of the Environmental Protection Agency.

Judy Sorum Brown is an educator, consultant, writer, and poet who works with organizations engaged in change, and teaches leadership and management at the University of Maryland.

Linda Cooper is a photographer based in Evanston, Illinois. She finds that her observational skills from 30 years of corporate/consulting work and from a long-time passion for photography nicely complement each other.

Surinder Deol is a senior learning specialist in The World Bank's Leadership Development Group. He teaches in Team Leadership and other programs.

Lilly Evans is Director of Mindful Learning at Strategic Learning Web, an organization specializing in "mental workouts" for senior executives.

Jay W. Forrester is Germeshausen Professor Emeritus of Management, MIT Sloan School of Management, with a strong interest in the use of system dynamics in pre-college education.

Gary Hamel is founder and Chairman of Strategos, Visiting Professor at the London Business School, and Distinguished Research Fellow at the Harvard Business School.

Stella Humphries is a Director of Research at the Society for Organizational Learning and a Research Affiliate at the Massachusetts Institute of Technology.

Edward Joyner is the Executive Director of the School Development Program at the Yale Child Study Center.

Richard Karash is a consultant and facilitator covering a broad range of Learning Organization disciplines, with special emphasis on Systems Thinking.

Jennifer M. Kemeny is a Principal with Innovation Associates, an Arthur D. Little company. She specializes in systemic approaches to organizational effectiveness.

Daniel H. Kim is an organizational consultant, co-founder of the Center for Organizational Learning at MIT, a trustee of the Society for Organizational Learning, and publisher of The Systems Thinker newsletter.

Barbara Lawton is an e-Business Strategist at Transaction Information Systems, Inc., who specializes in the role of knowledge in business.

Anil Paranjpe is Senior Consultant, Center of Excellence for Learning at Mahindra British Telecom Ltd. He is working on the exploration and implementation of concepts related to organizational learning, including ancient wisdom, community building, and ecosystems.

Linda Pierce provides support to the Shell Oil Company's Executive Leadership Team.

C. Otto Scharmer is a lecturer at the MIT Sloan School of Management and University of Innsbruck, Austria, and a research partner at the Center for Generative Leadership.

Peter M. Senge is a senior lecturer at the Massachusetts Institute of Technology and chairperson of the Council of Trustees of the Society for Organizational Learning.

Emily Sper is an artist in Boston, Massachusetts. Her photographs have been exhibited in the US and abroad.

Ray Stata is one of the founders of Analog Devices, Inc. and is currently chairman of the Board. An MIT graduate, he is a member of the MIT Corporation and serves on the Executive Committee.

John D. Sterman is Standish Professor of Management and Director of the System Dynamics Group at the MIT Sloan School of Management.

Joel Yanowitz is a Managing Director of Arthur D. Little's Organization Practice in North America. He works with executive teams to design and implement large-scale change initiatives.

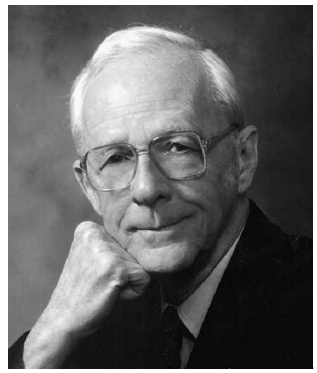
CLASSIC

A New Corporate Design (1965)

Jay W. Forrester

During the last 15 years there have emerged several important new areas of thinking about the corporation, its purpose, and its management. When brought together, these ideas suggest a new kind of organization that promises major improvements in the way the corporation can serve the needs of man. As yet, no such synthesis has been implemented.

In technology we expect bold experiments that test ideas, obtain new knowledge, and lead to major advances. But in matters of social organization we usually propose only timid modifications of conventional practice and balk at daring experiment and innovation. Why? Surely it is not that present organizations have proven so faultless. Nor can it be a matter of risk, for we spend far more and drastically affect the lives of more people with scientific and product experiments, many of which fail, than would be necessary in experiments with new concepts of corporate design. Perhaps we are victims of a preoccupation with scientific experiment. Perhaps knowledge is so compartmentalized that no one person sees at the same time the evidence of need, the possibility of improvement, and the route of advance. Perhaps we are reluctant to permit changes in the framework of our own existence. But it is time to apply to business organizations the same willingness to innovate that has set the pace of scientific advance.



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Jay W. Forrester
Professor Emeritus, MIT Sloan School of Management

Basis for a New Organization

Innovation can only be based on new ideas. These are now available. Four areas of thought, developed in the last two decades, form the foundations for the new type of organization that is here proposed. These four areas cover quite different aspects of the corporation but together they offer a mutually enhancing basis for a new type of enterprise:

1. New thinking in the social sciences indicates that moving away from authoritarian control in an organization can greatly increase motivation, innovation, and individual human growth and satisfaction.[1]
2. Critical examination of trends in the structure and government of corporations suggests that the present superior-subordinate basis of control in the corporation should give way to a more constitutional and democratic form.[2]
3. Recent research into the nature of social systems has led to the methods of "industrial dynamics" as a way to design the broad policy structure of an organization to enhance growth and stability.[3]
4. Modern electronic communication and computers make possible new concepts in corporate organization to increase flexibility, efficiency, and individual freedom of action.[4]

When these four lines of thinking are synthesized into a new, internally consistent structure, we find that they point to a very different kind of organization from that common in business today.

Reprinted from "A New Corporate Design" by Jay W. Forrester, *Sloan Management Review*, vol. 7, no. 1, Fall 1965, pp. 5-17, by permission of publisher. Also available in Forrester, J. W. "Collected Papers of Jay W. Forrester." (Waltham, MA: Pegasas Communications, 1975).

Characteristics of the New Organization

The proposed organization can perhaps best be conveyed by discussing 11 of its most conspicuous characteristics.

Elimination of the Superior-Subordinate Relationship

The influence of organizational form on individual behavior is central to the proposed corporate structure. A substantial body of thought, derived from several centuries of politics, national government, economics, and psychology, exposes the stultifying effect of the authoritarian organization on initiative and innovation and suggests that, whatever the merits of authoritarian control in an earlier day, such control is becoming less and less appropriate as our industrial society evolves.

From industrial history, the social sciences, and the observation of contemporary organizations, there emerges a relationship between the methods used for organizational control and the effectiveness and growth of individuals within the organization. The authoritarian and bureaucratic control structure molds individual personality so that the environment is seen as capricious, and lacking in orderly structure and in cause-and-effect relationships. Consequently the individual feels little hope of changing that environment and is not open to information and observations that would lead to improvement (Hagen, 1962).

If the authoritarian hierarchy with its superior-subordinate pairing is to be removed, it must be replaced by another form of discipline and control. This substitute can be individual self-discipline arising from the self-interest created by a competitive market mechanism.

To depart from the authoritarian hierarchy as the central organizational structure, one must replace the superior-subordinate pair as the fundamental building block of the organization. In the new organization, an individual would not be assigned to a superior. Instead he would negotiate, as a free individual, a continually changing structure of relationships with those with whom he exchanges goods and services. He would accept specific obligations as agreements of limited duration. As these are discharged, he would establish a new pattern of relationships as he finds more satisfying and rewarding situations.

The guiding policy structure and accounting procedures of the system must be so adjusted that the self-interest of the individual and the objectives of the total organization can be made to coincide. Education within the organization must then prepare each individual to use his opportunities in that self-interest.

The non-authoritarian structure implies internal competition for resource allocation. Prices of individual skills, capital, and facilities would rise to the highest level that could be profitably recovered by the various managers who sell to the outside economy. An internal price that is higher than an external price for the same resource would reflect a more efficient and effective internal use of that resource than is possible in the external economy. Such internal competitive allocation of resources would contrast to allocation by central authority as is now practiced by industrial corporations.

Individual Profit Centers

If resources are allocated not by the edict of higher authority but according to the value of the resource to the individual members of the organization, there must be a basis on which each member can estimate that value. In our economy outside the corporation, price is established in the long run by competitive conditions at a level that allows a profit to both buyer and seller. To achieve a counterpart within the new organization, each man or small team (partnership) should be a profit center and a decision point responsible for the success of those activities in which the center chooses to engage.

Much has been written about profit centers in the cor-

poration. In the larger corporations, profit responsibility is often decentralized to divisional profit centers. Yet, even in the most extensive present use of the profit center concept, only a tiny percentage of the individuals in the organization are personally involved in a profit center frame of reference to guide their own decisions and actions.

The profit center concept is very different from the budget center concept which is so common in financial planning and control. In a budget center the individual governs himself relative to a negotiated expenditure rate. The objective within the budget center is often to negotiate the highest expenditure rate possible (because salary and status are associated with number of employees and size of budget) and then to spend the full budget. Indeed, there are often pressures to overspend because next year's budget is related to this year's expenditures. The budget measures performance in terms of cost compared to promised cost and not in terms of cost compared to accomplishment.

The budget system of control sets up two conflicting chains. On one side are the functional activities responsible for accomplishing the work of the corporation—research, engineering, production, and sales. In each of these functional areas are pressures to accomplish as much as possible, to hire as many people as possible, and to spend as much money as possible. Since these tendencies toward excess can not go unchecked, there must be an opposing group, such as the controller's office, to impress financial restraint on the first group. The resulting conflict between pressures toward excesses and restraint of those pressures can only be resolved at higher authoritarian levels in the corporation. Once a control system is established that is not based on self-restraint, the authoritarian structure becomes necessary to resolve conflict. Efficiency, motivation, and morale decline rapidly as the command channels become choked, and as the decision-making point becomes so remote from operations that first-hand knowledge is inadequate for sound decisions.

. . . a profit center values activity and resources in terms of the difference (profit) between input costs and a sale price that is acceptable to others in a competitive market.

In contrast to a budget center, a profit center values activity and resources in terms of the difference (profit) between input costs and a sale price that is acceptable to others in a competitive market. The incentive is to maximize the difference between cost and value, to produce the most value for the least cost, and to reduce expenditure of time and resources where this can be done without a more than corresponding reduction in the value of the product. To be effective, rewards at the profit center, both financial and psychological rewards, must depend on profit and not on expenditure rate.

The way in which the profit accounting is done and the manner in which rewards depend on profit become of the utmost importance when these are the measures of success. The possible rules for this accounting cover a broad range. It is here that the self-interest of the individual is determined. It is in the profit center accounting rules that the individual meets the policy structure of the organization. It is here that individual self-interest and the objectives of the organization must coincide if a unity of purpose is to be sustained. It is here that the proper balance must be struck between long- and short-term objectives. It is here that the intended pressures must be created for adequate planning, for quality, for integrity, and for stability and growth of the organization as a whole.

The profit center provides the incentive to start new activity but, perhaps even more important, it must create pressures to discontinue old activities. Stopping an activity at the right time is one of the most important management functions. Too often, termination is delayed because it must be forced on an operational group having personal incentives to continue. In this conflict, termination can be imposed only when the external evidence for stopping the activity becomes overwhelming. Since emphasis should focus on the total life cycle of an undertaking—successful beginning, successful midlife management, and successful termination or transfer—profit center accounting for determining personal compensation should usually occur at the closing of an account and be measured against a compounded return-on-investment basis that extends over the total life of the activity.

The detailed accounting procedures are beyond the scope of this paper. Initially the accounting rules can only be tentative because they will almost certainly need to be changed after observation of the pressures they create in the organization. Unintended

pressures, or inadequacy of intended pressures must be corrected at their source by changing the accounting methods, not by building a body of compensating rules that would have to be implemented by a super-imposed authoritarian control structure.

In the profit center structure there will be similarities to the various legal entities in the outside economy. Some persons will offer personal services as advisors and consultants, others as contractors taking engineering and manufacturing commitments at a bid price, some as promoters and entrepreneurs to coordinate internal resources to meet the needs of the market, and still others in the role of informed investors to allocate the financial resources of the organization where the promise is greatest. Several procedures of the outside economy, such as the cost-reimbursement contract, which reduce the incentive for efficiency and tend to reimpose the budget method of control, would be prohibited.

Objective Determination of Compensation

If each profit center is designed to provide a sufficient measure of performance and if the centers correspond to individual people or small groups of people, then salary and bonus compensation can be determined automatically from the accounts of the center. Each man identified with the center would have a status similar to that of an owner-manager.

Above average performance, as shown in the profit center accounts, would lead to bonus payments, perhaps distributed into the future to give greater personal income continuity. If high performance persists, repetitive bonus payments would be the signal, according to a formula, for base salary increases to transfer more of the man's compensation to a stable income basis.

. . . income results from the value set on the man's contribution by peers who negotiate for his service.

An "objective" determination of salary here means one that is not the subjective setting of one man's income by the judgment (often interpreted as whim or caprice) of a superior. Instead, income results from the value set on the man's contribution by peers who negotiate for his service. For this peer evaluation to produce more effective internal alignments, there must be enough internal mobility so that the man can find the more satisfying situations. He must have unhampered freedom to test the value of his contribution in a variety of competing outlets. The objective measure of value rests on the freedom to move away from any situation which he believes to result in an unfair evaluation of his worth.

Policy Making Separated from Decision Making

Policies and decisions are conceptually very distinct from one another although they are intermingled and confused in much of the management literature.

Policies are those rules that guide decisions. The policy treats the general case and at least partially defines how specific decisions under that policy are to be made. Conversely, a decision takes the status and information of the system and processes it in accordance with the guiding policy to determine current action.

In their effect on human initiative and innovation, four measures of policy are important—freedom, accessibility, source, and consistency:

By the first measure, policies can differ in freedom, that is, the extent to which they determine the encompassed decisions. A fully defining policy completely determines the decision as soon as the values of the input variables are available; that is, when the existing conditions that are recognized by the policy have been measured, the rules of the policy are explicit and complete and the decision can be routinely computed. Such a policy leaves no freedom of action and can be automatized in a computer as are the policies for ordinary accounting procedures. On the other hand, a policy can establish a boundary within which the decisions must be made but with freedom remaining to adjust the decisions to personal preference or to information that was not foreseen by the policy.

By the second measure, policies can differ in accessibility, that is, the extent to which they are known to the decision maker. That decision maker is in a difficult and frustrating position who must act without being able to discover the policies which are to govern his actions. This inaccessibility of the guiding policies may arise for any num-

ber of reasons—the policies may exist but be undetectable, they may exist and be known but be subject to capricious change, or they may be nonexistent until a decision has been made which then may precipitate a contrary and retroactive policy.

By the third measure, policies can differ in source. Personal satisfaction with policies probably varies along the axis marked at one end by self-determined policies that govern one's own and others' decisions to, at the opposite extreme, policies imposed by another who establishes those policies unilaterally for his own benefit. In a democracy, the source of policy is intermediate between these extremes, being established by compromise between the citizens in a search for the greatest average satisfaction.

By the fourth measure, policies can differ in consistency, that is, freedom from internal contradiction. Often one finds policy structures in which the parts are so fragmented and unrelated that the separate policies operate at cross purposes. Examples are seen in emphasis on ever-greater sales even with hesitance and conservatism in expanding productive capacity, in stress on quality and customer satisfaction even while overloading the organization until it can perform only poorly, and in the unresolved conflict between pressures for short-term success and long-term strength. Contradictory policy is apt to arise where policy is an interpretation of decisions rather than vice versa. When decisions are made on the basis of local expediencies and policy is formulated to fit, the policy structure becomes an assembly of unrelated pieces. If policy is to be internally self-supporting and consistent, it must reflect a systems awareness. Each part of the policy structure must be appropriate not only to its local objective but must interact with other policies in a manner consistent with the over-all objectives of the total system. In the complex feedback system structure of an economic enterprise, consistent policy can hardly be created in bits and by happenstance.

As measured along these four dimensions—freedom, accessibility, source, and consistency—policy often operates in a manner that is unfavorable to individual effectiveness. Policy is most suppressive of innovation when it completely defines action and states exactly what is to be done. Policy is most frustrating to initiative when it is undeterminable and subject to future definition and retroactive application. Policy is most antagonizing when it is imposed on a subordinate for the benefit of the superior. Policy is most confusing when it is internally inconsistent and provides no guide for resolving conflicting pressures. These undesirable extremes are closely approached in some corporations.

By contrast, the more successful corporations are characterized by policies that give coordination without confinement, clarity of forbidden action, objectives that balance the interests of all, and consistency that reduces unresolved conflict. Yet it would appear that only the rare corporation goes far enough in even one of these four measures of desirable policy and none go far enough in all.

Policy should allow freedom to innovate and should have the fewest restrictions compatible with the coordination needed to insure overall system strength, stability, and growth. Policy should be accessible, clear, and not retroactive. The source of policy should be a process that ensures some consensus by those affected that it is a just compromise for the common good. Policies should be consistent by being designed as parts of a total policy structure that creates the desired dynamic behavior in the resulting system. Recent advances in the theory of dynamic systems and in system simulation using digital computers demonstrate that it will be possible to design internally consistent policy structures directly, rather than inferring corporate policy from the implications of past decisions.

Creating such a policy structure, and maintaining it as conditions change and new insights are acquired, would be a full-time task for a small number of the most capable men in a corporation. The past and present of the corporate system must be studied as a background for designing policy changes which will create pressures and incentives toward an improving future.

Policy making ought to be separated from the distractions of operational decision making; otherwise, short-term pressures will usurp time from policy creation, which can always be postponed to the future. Policy making ought to be separated from decision making to give a more objective and impartial outlook to policy design. Policy making ought to be separated from decision making so that the source of the policy is specific and responsibility for policy is clear.

Restructuring Through Electronic Data Processing

Vast amounts of electronic communication and computing equipment have already been installed for business data processing. Yet, the equipment is used almost entirely for tasks of the type that were previously done manually. Emphasis has been on doing more data processing within the earlier patterns, or on reducing the cost of work already being done.

The inadequacy of today's data processing objectives is exposed by industrial dynamics studies of corporate systems that show how behavior depends heavily on classes of information channels and decisions that are not today being supported by the electronic equipment. In these more important channels, information flow is haphazard, information is late, information is biased by human filtering, and error is frequent. Computers provide the incentive to explore the fundamental relationship between information and corporate success.

Part of the policy design task is to identify the relative importance of the various decision points and to determine the quality and fidelity needed in each information input. When this is done, information channels will be emphasized which are very different from those presently receiving attention.

Information networks can take several forms. The networks of most organizations are in the form of a complex mesh with many information repositories and large numbers of interconnecting channels. Another kind of network, made possible by the digital computer, takes the form of an information storage and computing hub with radiating spokes to each source or destination.

In the mesh network type of information system that is now common, the task of information storage and processing is subdivided to many small centers. Information is handled in batches, and files lag behind the status of the real-life system that they represent. Also, much of the information must be processed in series through several centers and there are large "inventories" of in-process information scattered throughout the system. Information retrieved from the system to guide decisions does not reflect past actions that are still being recorded and processed. This is often true even in the simple accounting and sales information that is now being handled by electronic computers. It is universally true and seriously detrimental in those informal information channels and decisions at the higher management levels. The mesh network becomes impossibly complex as the number of centers increases, particularly if each center is allowed to interact with every other center. A partial simplification has been achieved in practice by restricting communication channels to the inverted tree pattern of the formal organization chart. When this is done, lateral communication becomes slow and circuitous.

In the mesh network, substantial time and energy are consumed by internal communication that is made necessary by the dispersed storage of information. As a result, the organization becomes preoccupied with itself. It becomes inward looking with vast numbers of internal channels, the maintenance of which draws attention away from the contacts between the organization and the outside world. The organization consequently makes too little use of new technical knowledge; it loses contact with new market trends; and it is insufficiently aware of customer attitudes. These communication difficulties can be alleviated through a complete restructuring of the information system.

© Linda Cooper

Modern electronic equipment permits a rearrangement of the information system into a radial or star shape with all files at the center. "On line" use of computers for both data processing and internal communication can provide an information picture that is up-to-date and fully processed at all times. Partially processed inventories of information can be substantially reduced, along with a reduction of the internal communication needed to estimate conditions that are not yet reflected in the formal data.

With such a restructured system, information will be directly accessible to persons that now must operate with too little information either to permit good management or to establish a feeling of security and confidence. If the in-

ternal information can be reduced, energy can be turned to the even more challenging quest for external information—information about new technical developments, new management methods, new employees, customer satisfaction, product performance in the field, and changing markets.

Freedom of Access to Information

Much of the character and atmosphere of an organization can be deduced from the way it internally extends and withholds information. Corporations are almost all built on the authoritarian hierarchy structure but corporations differ greatly as to the basis on which authority and status are maintained within the hierarchy. In healthy organizations, authority tends to rest on generally recognized ability, ability which is great enough that it need not be excessively bolstered by information monopolies. In an authoritarian position that is not based on recognized ability, security may simply derive from the structure of the bureaucracy and the prerogatives of the office, or, position may be maintained by withholding information from both superiors and subordinates.

To possess information is to possess power. A monopoly of information can give a form of security. There are, in all organizations at all levels, a selective withholding and extending of information. Sole possession of information can make others dependent on oneself. Withholding of information can limit the scope and power of others' actions and reduce the threat to oneself. Control of information channels can isolate certain persons from the remainder of the organization and keep them within one's own sphere of influence.

Most persons in most organizations feel that they do not have access to all the information they need. Sometimes they lack the information specifically needed to accomplish their duties. Very often they lack the information needed to create a sense of security and a belief in the fairness and rationality of the system of which they are a part.

Information is often withheld to forestall questions about an authoritarian decision that has no rational defense. The availability of salary information illustrates the point. Wages of workers in a union situation may be generally known because the contract rules have been made explicit; information about individual compensation is made available to show that the rules are being followed. Conversely there are rules to justify the wage so that a subjective decision need not be defended. At the top of the hierarchy, executive salaries are published to stockholders along with information to implicitly or explicitly justify those salaries. In public service, salaries are set by law and are public knowledge. It is in the middle level of the corporation that one finds the greatest secrecy in salary details; this middle level is where salary determination is most subjective and where a guiding policy is least available. One can generalize to the observation that the more obscure the reasons for a decision, the greater are the inclinations to hide both the decision and the information on which it was based.

An organization can be seriously handicapped by the loss of energy consumed in the struggle for information. Time is occupied by attempts to obtain and to hide information. Psychological energy is drained by the nagging belief that others are withholding information that one needs, and by concern lest others learn information that one hopes to withhold.

Just as the individual hoards information, so does the organization as a whole. Competitive position is often believed to rest on secrecy to a far greater extent than is the fact. Information is withheld from individuals inside the organization on the excuse that this keeps information from outsiders. Secrecy is a poor foundation for success compared with competence, and to maintain secrecy reduces competence.

Although one will never succeed in making all information fully available, the goal can be pursued. Access can be given to the information that is recorded in the formal data system of the corporation. Incentives, both the incentive of convenience and the incentives designed into the accounting system, can encourage the entry of information into the central data files, from which it can be electronically retrieved. Design studies of the corporate data system will show the importance of converting many of today's informal information channels to ones in which regular observations are measured and recorded.

A general principle of the new organization should be to give much wider and more ready access to information than is now the usual practice. This can be accomplished

by reducing restrictions on information availability, by designing the social and incentive structure to favor the release of information, and to gather and record information in important channels that often remain on an informal basis.

Elimination of Internal Monopolies

On the national level monopolies are forbidden because of their stultifying influence on economic efficiency. Yet within corporations monopolies are often created in the name of presumed efficiency and are defended as avoiding duplication of effort.

For most activities the economies of scale are not as great as commonly supposed. In many situations where economy is expected from a larger activity it is easy to see that lower efficiency is, in fact, resulting. Very often the problems of planning and coordination rise so rapidly that they defeat the economies from larger size. This is particularly true of many of the service activities such as shops, drafting rooms, and purchasing offices.

Even where the activity itself may become more efficient in terms of local measures, the efficiency of the total organization may suffer. For example, in the consolidation of model shops, higher shop efficiency may result from a greater load factor on machines and machinists. However, the consolidated shop, now administratively separated from the technical activities, is less responsive to need, requires negotiation of user priorities, and may well cost substantially in the valuable technical and management time of senior people on whom the success of the organization depends.

A general principle of the new organization should be to give much wider and more ready access to information than is now the usual practice.

It should be a principle of the proposed organization that every type of activity and service must exist in multiple. No person is limited to a single source for his needs. No person is dependent on a single user of his output.

Only by eliminating the monopolies of the normal corporate structure can one have the efficiencies and incentives of a competitive system and provide objective and comparative measures of performance.

Balancing Reward and Risk

The new organization should retain and combine the advantages of earlier organizational forms while minimizing their disadvantages. One wishes to combine the stability and strength of the large, diversified business organization with the challenge and opportunity that the small company offers to its founder-managers. At the same time one must avoid the stifling bureaucracy and compartmentalization that is frequent in large organizations wherein the central power holds the right to allocate resources and make decisions. For the larger companies, competition exists on the outside but has no direct and often little indirect personal influence on those inside, except at the top levels of management. Conversely, the extreme risk and threat of failure in the small organization must be minimized since this repels many who might become effective independent managers.

In today's "small-business" world, the risk to the budding entrepreneur is greater than it need be. In general he gets but one chance. There is no opportunity to practice and to improve ability if the first undertaking is not a success. Penalty for failure should be reduced to a tolerable level but not eliminated. This can be done by risk sharing, not unlike the concept of insurance against catastrophe. The penalties should be just high enough to identify and dissuade the manager who repeatedly fails. Rewards should attract and encourage the competent and be high enough so that a normal quota of successes will more than carry the burden of occasional failures.

Offsetting part of the successes to cover the cost of the failures is now done by risk investors in the financial community but under circumstances unfavorable to the individual who seeks financial help. The investor is interested in a quick return on his investment. He has neither the skill nor the opportunity to substantially increase the ability of the new manager, or even to judge that ability in advance. The investor in new ven-

tures is forced into a sorting process of trying prospective managers, staying with the successes, and dropping the failures as soon as they are so identified. Such a process must be contrasted with a more ideal one in which the individual grows from initially managing his own time, to managing small projects, to becoming an entrepreneur who matches customer needs to the abilities of the organization. This evolution without discontinuity from individual worker to entrepreneur can stop or be redirected at any point. At each stage a history of performance is available to the man and to his potential supporters as a basis for deciding the next stage of his growth.

It follows that specific undertakings must be small enough so that the total organization can survive any individual failure. A favorable over-all ratio of success to failure must rest on the greater efficiency instilled in the organization, the greater competence created by the internal educational system, and the personal growth induced by the freedom, competitive challenge, and greater opportunities for the individual.

Mobility of the Individual

In the new organization, in contrast to the conventional corporation, the individual should have much greater freedom of internal movement, and greater ease of voluntary exit, but more restraint on entry.

The non-authoritarian structure with its internal competitive characteristics lays the basis for internal mobility so that work relationships can continually change toward those that are more satisfying. This potential mobility must be made real by an educational system that prepares the man for new opportunities and by an accounting system that creates pressures to prevent reversion to the superior-subordinate relationship. The latter is one of the many pressures that must be created by the design of the data processing system. For example, mobility should be enhanced by limiting, in the profit center accounting, the credit allowed for income from any one source that exceeds a specified fraction of the year's activity. This would create pressures on each individual to maintain several activity contacts, making it easier for him to gradually shift toward the ones that are more desirable.

Most corporations have reward structures designed to discourage men from leaving. Pension funds and stock options have rules that penalize the manager who leaves before retirement age. The worker is under similar pressures generated by pension rights and union seniority.

The negative consequences of this immobility are serious to the health of the organization just as immobility can retard a country's economic growth. Dissatisfied persons, who therefore lack dedication to their work, stay in the organization rather than finding a position elsewhere to which they are better suited. The suppressed turnover rate in personnel makes it easy for management to ignore undesirable internal conditions which might be quickly corrected if they were emphasized by a higher personnel departure rate. Furthermore, we can assume that people who are unwillingly present are less likely to grow to greater competence and responsibility. Finally, the restrictions on leaving fail in their primary purpose by having little effect on the most competent men whose self-confidence and security lie in outstanding ability.

The new organization should hold people because they want to be part of its kind of society. Any rights or deferred compensation that have been earned by past performance should be readily transportable if the man decides to leave. In fact, one might go further and visualize a placement office to assist any member of the organization in looking for a more attractive outside opportunity. If he finds one, the organization should reexamine itself to see if it is failing to offer the superior environment that is one of its principal objectives. If the man does not find the outside more attractive, he may become even more dedicated to the organization of which he is a part.

Mobility from the outside into the new organization is a different matter. Life in the organization would be very unlike most people's prior experience. The organization would be suitable for only a small fraction of them. It may well be that, if he has adequate information on which to base his decision, a man can judge his own compatibility with the organization more accurately than those within can judge for him. The

mutual decision by the applicant and the organization should be based on a far deeper acquaintanceship than precedes employment in most companies. This might be achieved through a series of study and discussion seminars that would expose the applicant, and perhaps his wife also, to the philosophy, history, psychological basis, objectives, and people of the organization.

The growth and stability of the total organization would depend on the mix of human resources and their rate of entry. The overall policies must provide guidance and incentives for bringing in the proper skills. For this reason also, the inward mobility can not be as free as interior or outward mobility.

Enhanced Rights of the Individual

Thoughtful writers on the evolution of the corporation have raised challenging questions about the sources and legitimacy of corporate power and its effect on those involved. By law, power rests with the stockholders; but in practice, stockholders have little control over either the acts or the selection of management. Considering the emerging concepts of social justice, there is serious doubt about the moral right of stockholders, acting through management, to the arbitrary power which can now be exercised over individual employees, particularly those in the middle management and technical groups. The precedents set in the last several hundred years by changes in the form of national government suggest that corporate power will also evolve from the authoritarian toward the constitutional. With this evolution, the primary objectives of the corporation would change from the already diluted idea of existence primarily for profit to the stockholders and toward the concept of a society primarily devoted to the interests of its participants.

The present day protection of the employee against the exercise of arbitrary power by the corporation is weak and unevenly distributed. Production workers, by joining together in unions, have won a few fundamental individual rights regarding seniority, grievance procedures, and rights of arbitration. But, as one moves up the corporate hierarchy, the subordinate has progressively less security against arbitrary decisions by the superior. It is in the technical and management levels, where initiative and innovation are so important, that we find most unrestrained that suppressor of initiative and innovation—capricious, arbitrary authority.

The new organization should develop around a "constitution" that establishes the rights of the individual and the limitation of the power of the organization over him.

The new organization should develop around a "constitution" that establishes the rights of the individual and the limitation of the power of the organization over him. Corporate policy would be subject to corporate constitutional provisions just as the national constitution has supremacy over laws made by national legislative bodies. To complete the system, there must be means for "judicial review" by impartial tribunals to arbitrate disagreements and to interpret into illustrative precedent the operational meaning of the constitution and policies of the organization.

Education Within the Corporation

A modern national democracy rests on an extensive body of tradition and a high level of public education without which the democratic processes fail. This failure has been manifest in the turmoil during the formation of new nations. Without a foundation of education and tradition, premature democratic governments quickly revert to authoritarian regimes. By contrast, democracy in Western Europe and the United States now rests on a massive base of education and on deep traditions regarding the rights and responsibilities of the individual.

A corresponding foundation must support the new type of "industrial democracy" that is here being proposed. Such a base of education and tradition lies as far beyond the background possessed by today's average manager and engineer as the United States public background of democracy lies beyond that in the underdeveloped nations. The cycle of change can begin with education that guides practice which matures into different organizational traditions.

The more effective education of the future must permit man's transition to a new, higher level of abstraction in the economic process. The last such change in level of abstraction was man's entry during the last two centuries into our present industrial society. In the days of the craftsman, the most skilled in the population made the consumer products; but, in the more abstract atmosphere of industrialization, the most skilled have become the inventors and designers who create machines that, in turn, make the consumer products. The skilled designers now operate once removed from direct production.

At the same time, the structure for decision making changed radically to one in which the decisions are now more abstract because they are removed from the point of actual production. The need for coordinating many efforts caused a subdivision and specialization of decision making, similar to the specialization that is so evident in actual manufacturing steps. Where the craftsman had hardly been aware of the distinction between deciding and doing, the industrial society separates the decision from the action. Decision making is separated from the worker because the governing policy is implicit and subjective. It has not yet been clearly stated. Coordination has been possible only by centralizing decision making in one individual so that consistency might then come from all decisions being tempered by the same subjective policies. But for this coordination we pay a high price in personal values and in flexibility to innovate and to respond to changing circumstances. The separation of work from decision making, with the authoritarian system that it implies, has been at the root of the growing dissatisfaction with the present trend in corporate government.

In leaving our present stage of economic evolution and moving to a future "automation society," we must pass through another transition in man's relationship to production. In this still more abstract society, the most skilled, on whom the production processes depend, will be those who create the machines which in turn make production machines which, again in turn, produce goods. The most skilled will then be twice removed from actual production. This new complexity of industrialization has already begun.

The conceptual changes in management which must accompany our progress into the automation society are as sweeping as the change to centralized decision making that came with industrialization. In the new phase there must be another restructuring of the decision-making process.

Our understanding of the industrial system is now reaching a point where the policy necessary to guide coordinated decisions can be made explicit and the policy structure itself can be objectively studied and designed. As this explicit treatment of policy is achieved, policy making and decision making can be completely separated. Policy making can then be executed by a central group; and decision making, within the framework of the common policy, can be returned to the individual person.

In such a new industrial organization education must serve two purposes that are not essential in an authoritarian corporate government. First, understanding of the growth and stability dynamics that inter-relate psychology, economic activity, and markets must be adequate to permit design of a governing policy structure. Second, the citizens of the new corporate society must understand the origin, meaning, and purposes of the policy structure well enough to successfully conduct their affairs in a manner that combines individual freedom with group coordination.

In preparing men for our present industrialized society we already devote a third of each lifetime to education. One might ask how a still higher level of education is to be achieved. There are several answers.

First, as we climb to the next level of conceptual abstraction, much of the earlier educational process condenses into a new, rational framework. Specifically, as we come to understand the fundamental structure and dynamics of social systems, we can learn explicitly and directly the general concepts which earlier had to be taught indirectly by historical incident or learned slowly from personal experience. Most present-day teaching in the humanities and in management is by the "case method" of retracing specific situations, leaving to the student the task of extracting some general principles from the apparently conflicting descriptions. Now, as it becomes possible to work directly with the pertinent system structures in the context of system theory and laboratory simulation, it becomes clearer how certain fundamental characteristics of social systems can produce the diverse modes of behavior that are observed. An understanding of social systems can be acquired

much more rapidly if learning can be based on an explicit system rationale than if this rationale is only dimly and intuitively perceived.

Second, time for education can be obtained in the work environment if the confusions and distractions in present practice can be reduced by a clearer structure and a more efficient coordinating process. Estimates indicate that many of today's organizations consume 25 percent or more of their potential effectiveness trying to coordinate internal activity. Much of this coordination is necessary simply because the organization is overloaded and trying to produce beyond its true capability. As the organization tries to do more in the short run, the costs rise rapidly in terms of confusion, coordinating and planning personnel, resolving priorities, and pacifying dissatisfied customers. The toll is especially high at the creative levels of management and engineering. Policies that ensure slight underloading could leave the same actual productive output and make the time now lost through attempted overloading available for a continuing educational program.

Third, time for education will be economically feasible if it results in greater long-term effectiveness. Greater revenue resulting from a higher degree of initiative and innovation can be allocated partly to the educational program. If the organization maintains its vitality and continues to change in keeping with the times, it should sustain a high enough level of contribution to society to justify a perpetual rebuilding of the educational base.

Fourth, education might be more effective it could be properly coordinated with a man's development. This would require a true educational opportunity as a continuing part of the work environment. Then it would be possible to shorten a man's formal education at the college level and defer the study of many areas until work experience has indicated their importance and until learning motivation is higher. For example, engineers early see the importance of science but they may be well launched on their professional careers before they see reason to understand psychology, the dynamics of industrial systems, law, or even effective writing.

What, then, should be the place of education in the corporate strategy? The arguments are persuasive that some 25 percent of the total working time of all persons in the corporation should be devoted to preparation for their future roles. This means time devoted to competence some five years in the future and does not include the learning that may be a necessary part of the immediate task. Over a period of years this study would cover a wide range—individual and group psychology, writing, speaking, law, dynamics of industrial behavior, corporate policy design, advances in science and engineering, and historical development of political and corporate organizations—the extent and sequence being tailored to the individual person.

Such an educational program would differ substantially from any now offered. It must be derived from the same foundations and social trends as the new corporation itself. It must be at the same time more practical, but also more fundamental and enduring, than existing advanced training programs in either technology or management.

The educational program must become an integral part of corporate life, not a few weeks or months once in a lifetime at another institution. The overall policies of the organization must create incentives that protect the time for education from encroachment by short-term pressures. Because self-development is so easy to defer, the responsibility for personal growth should probably be shared by the individual and a "career advisor" whose own compensation depends on the growth and success of his protégés.

Analogy to National Economic Structure

The central feature of today's corporation is its authoritarian power structure, with the superior-subordinate pair relationship as the fundamental building block. Ultimate authority for all decisions lies at the top and this authority is delegated or withheld by the superior at each level. So entrenched in our thinking is this authoritarian structure that few people can visualize an alternative, yet our largest economic unit stands as a striking and successful contradiction.

The growth and strength of the United States as a whole rests on an economic structure in which the superior-subordinate relationship is absent. Legal entities, be they cor-

porations or individuals, are related to each other as equals. Corporations, doctors, lawyers, shop owners, independent contractors, and private businessmen interact with one another in a structure based on self-interest, not on the right of one to dictate to another. The United States' economic structure is not an exact pattern for the new organization. Yet the constitution and legal structure of the country offer many clues to answering the more difficult questions about the proposed organization.

The profit center concept of the proposed organization brings into the corporation the same free-enterprise profit motive that we believe is essential to the capitalist economy. The objective determination of compensation is the same process that determines the profitability of legal entities in the outside economy.

The stress on separation between policy making and decision making has its counterpart in the separation, on the one hand, between congressional and executive branches of the government and, on the other hand, between the policies set by law and the decision-making freedom left to the independent economic units. Laws, viewed as policy to govern economic activity, tend to be boundary policy stating what can not be done and leaving all else to the discretion of business decision makers. The counterpart of laws would be corporate policy designed to achieve adequate coordination while permitting individual freedom.

The educational program must become an integral part of corporate life, not a few weeks or months once in a lifetime at another institution.

Freedom of access to information within the corporation has its equivalent in the freedom of the press.

Anti-monopoly legislation rests on reasons that should prevail far oftener when corporations decide whether or not to combine similar functions.

Education as a major function of government has an equivalent in the emphasis that the corporation should place on preparing its people for the future.

Implementation of These Proposals

It is not implied that these ideas for a new corporate design are yet developed to a point where they would fit all types of businesses. But they do seem particularly suited to those industries which feel the impact of rapid change in science and technology and in which conventional management approaches have often been found wanting.

An experiment in organization should presume slow growth at first under conditions permitting revision because it must be realized that an enterprise as different as the one here proposed must test and evolve its most fundamental concepts as well as their implementation.

It does not seem likely that such sweeping changes could be implemented by gradual change within an existing organization. The new proposals represent a consistent structure; but they contain many reversals of existing practice. Introducing the changes piecemeal would place them in conflicting and incompatible environments; the changes would be contrary to existing traditions and would give rise to counter pressures high enough to defeat them.

The only promising approach seems to be to build a new organization from the ground up in the new pattern. It might be either a truly new and independent organization or a detached and isolated subsidiary of an existing corporation. It must feel its way, modify ideas where necessary, and create success at each stage as a foundation for further growth.

Notes

1. Hagen, Everett E. *On the Theory of Social Change* (Homewood, IL: Dorsey Press, 1962).
   McClelland, David D. *The Achieving Society* (Princeton, NJ: D. Van Nostrand Co., 1961).
   McGregor, Douglas. *The Human Side of Enterprise* (New York: McGraw-Hill Book Co., 1960).
   Likert, Rensis. *New Patterns of Management* (New York: McGraw-Hill Book Co., 1961).
   Haire, Mason. *Psychology in Management* (New York: McGraw-Hill Book Co., 1964).
2. Eells, Richard. *The Government of Corporations* (Free Press of Glencoe, 1962).
   Eells, Richard, and Clarence Walton. *Conceptual Foundations of Business* (Homewood, IL: Richard D. Irwin, Inc., 1961).

Berle, Adolf A., Jr. *The 20th Century Capitalist Revolution* (New York: Harcourt, Brace & World, Inc., 1954).

3. Forrester, Jay W. *Industrial Dynamics* (Waltham, MA: Pegasus Communications, 1961).
Roberts, Edward B. *The Dynamics of Research and Development* (New York: Harper & Row Publishers, Inc., 1964).
Packer, David. *Resource Acquisition in Corporate Growth* (Cambridge, MA: MIT Press, 1964).
Nord, Ole C. *Growth of a New Product* (Cambridge, MA: MIT Press, 1963).
4. The literature is notably weak in treating the philosophy of how electronic data processing can, in the long run, lead to restructured organizations and to environments more attractive to the individual. There has been a tendency to stress the negative short-run trends rather than to develop the positive aspects.

Reconsidering "A New Corporate Design"[1] (1993)

by Jay W. Forrester

Reading "A New Corporate Design" again left me with three reactions:

1. The paper fails current standards for "political correctness" with masculine pronouns throughout and with managers and employees referred to as "men." Even as one who feels that present changes in writing style have gone to extremes, I still found the paper jarring.
2. I now would alter the impression created in the section of the paper on "Individual Profit Centers." There is one sentence that clearly points in the right direction, "Since emphasis should focus on total life cycle of an undertaking—successful beginning, successful mid-life management, and successful termination or transfer—profit center accounting for determining personal compensation should usually occur at the closing of an account and be measured against a compounded return-on-investment basis that extends over the total life of the activity." But most of that section on profit centers can easily but unintentionally be read as endorsing measures of success based on current short-term profits.

   One must avoid rewards based on current operations. We should move away from present corporate practice in which salary and bonuses are based on the current year's performance. Such rewards favor short-term decisions for immediate personal advantage over long-term success of the organization. I believe that all rewards should be based on a final accounting. That final accounting could be at the completion of a specific task, such as the design of a circuit. But for a product manager responsible for carrying an idea from design through marketing, reward should be at the completion of the product life and closing of the activity, or at the "sale" of the activity as a going business to a willing buyer in the company who would assume the existing financial status and add the "purchase" price to the buyer's account. Only with program termination built into the accounting will individuals have incentive to stop activities at the optimum time.

   I do not believe that money is the primary source of motivation. Instead, freedom, recognition for a task well done, and absence of frustrations imposed by others are among the conditions that induce dedication to the task at hand. However, clearly defined financial rewards force designing an organizational structure that creates freedom, recognition, and absence of frustrating bureaucratic intervention.
3. I was struck once again by how difficult it is to change existing paradigms. The management paradigm based on an authoritarian structure is so deeply imbedded in people's thinking that alternatives can not be imagined. Radical alternatives are rejected as not even discussible.

The Authoritarian Paradigm

I use "paradigm" here in the sense of Thomas Kuhn,[2] meaning a frame of reference or a microscope through which to view the surrounding world. A paradigm restricts one's vision to seeing only what is expected and to accepting only what prior conditioning leads one to believe. Not often do the holders of a paradigm change even in the face of powerful evidence that the paradigm is faulty. More frequently, change arises through a new generation of people who find the old view unsatisfactory and who seek an alternative paradigm that better fits the social and natural world. The slow revision of paradigms is illustrated by the extreme case of Galileo who in the year 1633 was convicted of heresy

by the Catholic Church for his forceful and persuasive arguments that the earth is not the center of the universe but rather revolves around the sun. It was not until 1992, more than 350 years later, that the Catholic Church in Rome officially acknowledged that Galileo had been right.

The unshakable belief that "organization" inherently requires and implies an authoritarian hierarchy fits the concept of a paradigm. People believing in the authoritarian paradigm do not see or accept any other possibility.

Visualizing a radically different alternative to the authoritarian form of organization inside a corporation appears almost impossible for people who have been conditioned since birth by living in an authoritarian universe. Families, schools, and corporations operate on the basis of superior-subordinate relationships. The resulting authoritarian paradigm is overpowering.

Repeatedly we see the contradiction of prominent executives making speeches about the advantages of a free-enterprise economic system while they are running some of the largest authoritarian socialist bureaucracies in the world. In fact, modern large corporations are the breeding ground for socialism. Several characteristics describe a corporation: (1) centralized ownership of productive resources by the organization, (2) assignment of individuals to tasks by those higher in authority, (3) rewards to individuals determined by subjective judgment and personal interest of superiors, (4) barriers to emigration in search of a better life (through vesting in pension plans), (5) maintenance of personal power by restricting availability of information, and (6) appointment of leaders to office without democratic election by the workers in the society. Are not these the descriptors of an authoritarian socialist, or communist, or dictatorial government?

Corporate executives are usually unable to imagine an organization that operates without the superior-subordinate relationship. When I ask an executive for an example of an organization that operates without the superior-subordinate structure, a law partnership may be suggested. When I ask for a very large system operating without the superior-subordinate structure, nothing is forthcoming. Instead, such is considered impossible.

A Free-Enterprise Paradigm

Is it not remarkable that executives, who are captives of the authoritarian paradigm, almost never identify the largest non-authoritarian economic system, as a possible organizational alternative to the typical corporate structure? That well known alternative is the constitutional governmental form of the United States. Our largest economic structure, the national economy, rests on free enterprise negotiations in which there is no superior-subordinate relationship among legal entities—automobile companies, dentists, drug stores, consultants, individuals in their private lives, and construction companies all have equal status under the law, none can dictate to another merely through power arising from a superior administrative position.

Free enterprise as a basis for economic organization has existed for several hundred years in nations of the English-speaking world and Western Europe, but it has yet to be accepted by most other countries or as a basis for the internal organization of corporations. If our largest economic systems operate successfully as free-enterprise societies, why can not such structures exist within corporations?

"A New Corporate Design" represents an alternative to the authoritarian form of organization. The "design" starts by totally eliminating superior-subordinate relationships as basic organizational building blocks. Rebuilding from what might otherwise be chaos leads to a structure that parallels the constitutional organization of the U.S. national economy.

A free-enterprise corporation would:

- eliminate all superior-subordinate relationships.
- forbid internal monopolies, even at the point of allocating financial resources. As in the outside economy, there must be several internal competing "investment bankers" who are continually searching for people within the organization who will act as entrepreneurs to organize products, services, and markets. Conversely, people who have innovative proposals would have several alternative sources of support so that they would not be subject to the prejudices and caprice of a single allocator of funds.
- reward people on objective measures of return-on-investment success applied to the entire time that an individual is associated with a project or program. Individuals should receive bonuses automatically by known formulas for completed return-on-investment results above some specified threshold.
- assure mobility and freedom of association within the corporation by requiring that every separate accounting center receive no more than 40% of its annual income from any one source. This means that each center would have at least three clients and could shift work toward the most constructive relationships.

- develop a constitutional and contractual relationship with all participants such that no individual or small group would have the power to change the structure of the organization. As in a national democracy, change could come only through votes of corporate citizens. Fundamental concepts, as with a national constitution, would require more than a majority vote.

Notes

1. Reprinted for *Internal Markets: How to Bring Free Enterprise Inside the Organization,* John Wiley & Sons, New York: 1993. edited by Halal, Geranmayeh, and Pourdehnad
2. Kuhn, Thomas S., 1962. *The Structure of Scientific Revolutions,* Chicago: University of Chicago Press, 210 pp.

Daniel H. Kim
Organizational Consultant

Commentary by Daniel H. Kim

I first read "A New Corporate Design" almost 15 years ago as I was just getting my feet wet in the field of system dynamics. I remember being very struck by the power of the ideas Jay Forrester was articulating and excited about the possibility of creating the type of organization he was describing. In my youthful naivete, I was also a bit perplexed that 20 years had passed since the article was first published and yet most organizations appeared to have moved very little towards making the shifts Forrester outlined. I was personally convinced that creating organizations based on such ideas as the elimination of the superior-subordinate relationship, the creation of individual profit centers, having freedom of access to information, and enhancing the rights of the individual was a desirable thing to do, and I was eager to get going.

Re-reading his article today still strikes the same resonant chord in me, but I now have a much better appreciation of how deep the challenges are in creating organizations that are aligned around the set of ideas Forrester proposed. I also have a new appreciation of his comments at the end of the article where he wrote: "The only promising approach seems to be to build a new organization from the ground up in the new pattern." This is because "[i]ntroducing the changes piecemeal would place them in conflicting and incompatible environments: the changes would be contrary to existing traditions and would give rise to counterpressures high enough to defeat them." I hardly paid attention to those words when I first set out (with much idealism and enthusiasm) working to help implement the ideas contained in the article. Having now worked with dozens of organizations over the years, my own experience tends to support Jay Forrester's thesis. Indeed, the counterpressures are often high enough to defeat whatever changes may have succeeded in the short term.

Although starting new companies is one way of building this kind of organization from the ground up, I don't think that means that we must write off all existing organizations as hopeless. I believe that one of the central challenges we face in organizational change work is understanding how to define the appropriate organizational settings within which our efforts are likely to succeed and grow. An important insight that I am taking away from revisiting this article is the reminder that piecemeal solutions are not likely to work, which is consistent with Dr. Deming's twelve point approach to quality improvement and Peter Senge's five discipline approach to learning organizations. All of them emphasize the transcendental importance of the whole set (of ideas, principles, or disciplines) over the singular importance of any of the individual pieces. It is, not surprisingly, a *systemic* approach to organizational change.

Commentary by Georgianna Bishop

Forrester's insightful observation that organizational structures and governance need to change in order to meet rapidly changing technologies and social needs is as relevant today as it was in 1965. Today our public sector institutions serving financial, agricultural, health, defense, housing, environmental, and other societal needs are demonstrating the organizational and structural time warp that Forrester aptly describes. This time warp is alienating the very people whom these institutions were designed to serve.

Much of the existing structural inflexibility and centralized decision-making that Forrester describes was deliberately designed into our public institutions to prevent their mis-use for political gain. Thus, balancing flexibility in decision-making with protections against political manipulation

is a major challenge to restructuring public sector institutions. Over time, the policies and laws for which federal agencies are responsible contribute to fragmentation, redundancy, and silos of expertise. As these policies and regulations increase in scale and complexity, there is little incentive to review them for inconsistencies or long-term systemic implications.

The authors of our Constitution replaced English authoritarian hierarchy with a "superior-subordinate pair as a fundamental building block" that is still deeply rooted in our political and societal mental models. Every two-to-four years, our political process gives us the opportunity to elect officials who can, and do, appoint many of the leaders of our large federal agencies. In recent years, it has been popular for candidates for political office to promise wholesale reform and/or elimination of federal agencies. Paradoxically, their election promises and subsequent short-term attempts at reform (the same two-to-four years) have become predictable, and in large measure contribute to the inertia and fossilized structures that now compel a much deeper and longer-term approach. Public dialogue about government restructuring needs to move beyond short-term politics and election cycles.

Possibly, "we the people" need to change our expectations of government leaders, both elected and appointed. Possibly we need to assess their performance according to how well they align and simplify existing policies and systems, not how well they create new policies and systems that further fragment and overburden government institutions. The defining measure of success for re-election and re-appointment should be leadership that integrates and aligns employees, policies, and systems with organizational purpose. As complexity and fragmentation continue to increase, it is easy to see how federal employees lose their understanding and connection to the whole as well as their cause-and-effect relationships (both internal and external).

The greatest challenge for future leaders in the public sector is to re-engage their employees with the purpose of their organizations, and to reinvigorate those employees' belief in themselves and their hope for real change. The federal civil service system is designed, much as Forrester describes it, to reward employees for their length of service, not their performance. The performance level of the federal work force would rise dramatically with greater individual employee and management mobility. At the same time, human resource practices and employee development programs would have to change dramatically to keep pace with accelerated turnover.

If we want to strengthen professional leadership at the executive levels of government, we must give government organizations greater autonomy and more flexibility. Perhaps the public should take greater responsibility and interest in the leadership ability, relevant experience, and length of tenure of these senior government executives. Alternative government models exist in Europe, as well as in our own Federal Reserve Bank, Defense Department, and General Accounting Office.

Forrester's compelling argument for a new corporate design seems as real today for the business of government as it did in 1965. With a federal government that has the lowest public approval rating in its history, let's hope that we are ready to take on the challenges of restructuring government.

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FEATURE

Learning In and About Complex Systems

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Introduction

The greatest constant of modern times is change. Accelerating changes in technology, population, and economic activity are transforming our world, from the prosaic—how information technology influences how we use the telephone—to the profound—how greenhouse gases affect the global climate. Some of the changes are desirable, others defile the planet, impoverish the human spirit, and threaten our survival. They all challenge traditional institutions, practices, and beliefs. Most important, most of the changes we are now struggling to comprehend have arisen as consequences, intended and unintended, of humanity itself.

The dizzying effects of accelerating change are not new. Henry Adams, a perceptive observer of the great changes wrought by the Industrial Revolution, formulated a "Law of Acceleration" to describe the exponential growth of technology, production, and population that made the legacy of colonial America irrelevant:

> Since 1800, scores of new forces had been discovered; old forces had been raised to higher powers. . . . Complexity had extended itself on immense horizons, and arithmetical ratios were useless for any attempt at accuracy.
>
> . . . If science were to go on doubling or quadrupling its complexities every ten years, even mathematics should soon succumb. An average mind had succumbed already in 1850; it could no longer understand the problem in 1900. (Adams, 1918, pp. 490, 496)

Adams believed the radical changes in society induced by these forces "would require a new social mind." With uncharacteristic, and perhaps ironic, optimism, he concluded, "Thus far, since five or ten thousand years, the mind had successfully reacted, and nothing yet proved that it would fail to react—but it would need to jump."

A steady stream of philosophers, scientists, and management gurus have since echoed Adams, lamenting the acceleration and calling for similar leaps to fundamental new ways of thinking and acting. Many advocate the development of "systems thinking"—the ability to see the world as a complex system in which we understand that "you can't just do one thing," that "everything is connected to everything else." If people had a holistic world view, many argue, they would then act in consonance with the long-term best interests of the system as a whole. Indeed, for some, systems thinking is crucial for the survival of humanity.

There are many schools of systems thinking (for surveys, see Richardson, 1991, and Lane, 1993). Some emphasize qualitative methods, others formal modeling. As sources of method and metaphor, they draw on fields as diverse as anthropology, biology, engineering, linguistics, psychology, physics, and Taoism, and seek applications in fields still more diverse. All agree, however, that a systems view of the world is still rare.

The challenge is how to move from generalizations about accelerating learning and systems thinking to tools and processes that help us understand complexity, design better operating policies, and guide organization- and society-wide learning. However, learning about complex systems when you also live in them is difficult. We are all passengers on an aircraft we must not only fly, but redesign in flight. In this article, I review what

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we know about how people learn in and about complex dynamic systems. Such learning is difficult and rare because a variety of structural impediments thwart the feedback processes required for learning to occur. I argue that successful approaches to learning about complex dynamic systems require: (1) tools to articulate and frame issues, elicit knowledge and beliefs, and create maps of the feedback structure of an issue from that knowledge; (2) formal models and simulation methods to assess the dynamics of those maps, test new policies, and practice new skills; and (3) methods to sharpen scientific reasoning skills, improve group processes, and overcome defensive routines for individuals and teams; that is, in the words of Don Schön (1983a), to raise the quality of the "organizational inquiry that mediates the restructuring of organizational theory-in-use." Systems approaches that fail on any of these dimensions will not prove useful in enhancing the capabilities of individuals or organizations to understand, operate effectively in, or improve the design of the systems we have created and in which we live, nor can they form the basis for the scientific study of complexity.[1]

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Learning is a Feedback Process

All learning depends on feedback. We make decisions that alter the real world, we receive information feedback about the real world, and using that information, we revise our understanding of the world and the decisions we make to bring the state of the system closer to our goals (figure 1).

The feedback loop in figure 1 appears in many guises throughout the social sciences. In his history of feedback concepts in the social sciences, George Richardson (1991) shows how beginning in the 1940s, leading thinkers in economics, psychology, sociology, anthropology, and other fields recognized that the engineering concept of feedback applied not only to servo-mechanisms but also to human decision-making and social settings. By 1961, Forrester, in *Industrial Dynamics*, asserted that all decisions (including learning) take place in the context of feedback loops. Later, Powers (1973, p. 351) wrote:

> Feedback is such an all-pervasive and fundamental aspect of behavior that it is as invisible as the air that we breathe. Quite literally, it is behavior—we know nothing of our own behavior but the feedback effects of our own outputs. To behave is to control perception.

These feedback thinkers followed John Dewey, who recognized the feedback loop character of learning around the turn of the century when he described learning as an iterative cycle of invention, observation, reflection, and action (Schön, 1992). Explicit feedback accounts of behavior and learning have now permeated most of the social and management sciences. Learning as an explicit feedback process has even appeared in practical management tools such as Total Quality Management (TQM), where the so-called Shewhart-Deming PDCA cycle (Plan-Do-Check-Act) lies at the heart of the improvement process in TQM (Shewhart, 1939; Walton, 1986; Shiba, Graham, and Walden, 1993).

The single feedback loop shown in figure 1 describes the most basic type of learning. The loop is a classical negative feedback whereby decision makers compare information about the state of the real world to various goals, perceive discrepancies between desired and actual states, and take actions that (they believe) will cause the real world to move towards the desired state. Even if the initial choices of the decision makers do not close the gaps between desired and ac-

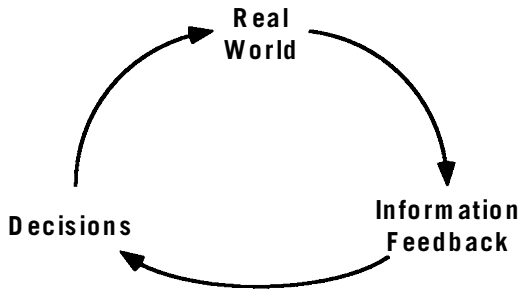

Figure 1. Learning is a feedback process. The feedback to the decision maker from the real world includes all forms of quantitative and qualitative information.

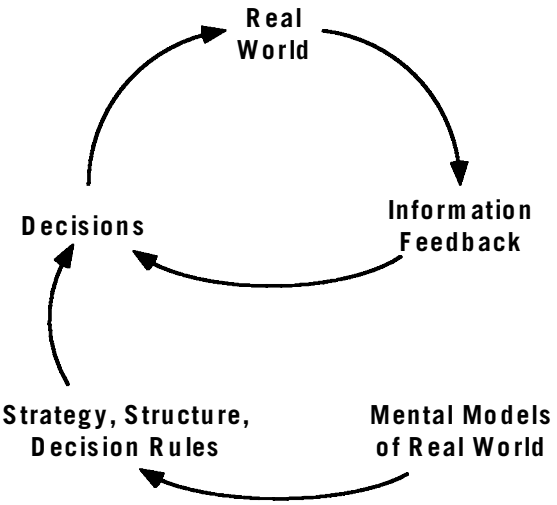

Figure 2. The learning feedback operates in the context of existing decision rules, strategies, culture, and institutions, which in turn derive from our prevailing mental models.

tual states, the system might eventually reach the desired state as subsequent decisions are revised in light of the feedback received (see Hogarth, 1981). When I am driving, I may turn the steering wheel too little to bring my car back to the center of my lane, but as visual feedback reveals my error, I continue turning the wheel until my car returns to the straight and narrow. If the current price for my firm's products is too low to balance orders with production, depleted inventories and long delivery delays cause me to raise the price gradually until I discover one that clears the market.[2]

The feedback loop shown in figure 1 obscures an important aspect of the learning process. Information feedback about the real world is not the only input to our decisions. Decisions are the result of applying a decision rule or policy to information about the world as we perceive it (see Forrester, 1961, 1992). The policies themselves are conditioned by institutional structures, organizational strategies, and cultural norms. These, in turn, are governed by the mental models of the real world we hold (figure 2). As long as the mental models remain unchanged, the feedback loop represented in the figure represents what Argyris (1985) calls single-loop learning, a process whereby we learn to reach our current goals in the context of our existing mental models. Single-loop learning does not deeply change our mental models—our understanding of the causal structure of the system, the boundary we draw around the system, the time horizon we consider relevant, or our goals and values. Single-loop learning does not alter our world view.

Mental models are widely discussed in psychology and philosophy. Different theorists describe mental models as collections of routines, scripts, or schemata for selecting possible actions; cognitive maps of a domain; typologies for categorizing experience; pointers from instances of a phenomenon to analogous instances; logical structures for the interpretation of language; or attributions about individuals we encounter in daily life (Axelrod, 1976; Bower and Morrow, 1990; Cheng and Nisbett, 1985; Gentner and Stevens, 1983; Halford, 1993; Johnson-Laird, 1983; Schank and Abelson, 1977; Vennix, 1990). The concept of the mental model has been central to system dynamics from the beginning of the field. Forrester (1961) stresses that all decisions are based on models, and provides a typology that classifies models between formal or mental, analytic or simulation, and so forth. In system dynamics, "mental model" stresses the implicit causal maps of a system we hold, and our beliefs about the network of causes and effects that describe how a system operates, along with the boundary of the model (the exogenous variables) and the time horizon we consider relevant—our framing or articulation of a problem.

Most people do not appreciate the ubiquity and invisibility of mental models. Instead, they naively believe that their senses reveal the world as it is. On the contrary, our world is actively constructed—modeled—by our sensory and cognitive structures. Figure 3 shows a Kanizsa triangle (named for the Yugoslav psychologist, Gaetano Kanizsa). Most people see a white triangle whose corners cover part of three dark circles and which rests on top of a second triangle with black edges. The illusion is powerful. Recent research shows that the neural structures responsible for the ability to "see" illusory contours such as the white triangle exist between the optic nerve and the areas of the brain responsible for processing visual information.[3] Active modeling occurs well before sensory information reaches the areas of the brain responsible for conscious thought. Powerful evolutionary pressures are responsible. Our survival depends so completely on the ability to interpret reality rapidly that long ago, we (and other species) evolved structures to build these models automatically. Usually, we are totally unaware that these mental models even exist. It is only when a construction such as the Kanizsa triangle reveals the illusion that we become aware of our mental models.[4]

Most people do not appreciate the ubiquity and invisibility of mental models.

The Kanizsa triangle illustrates the necessity of active and unconscious mental modeling or construction of "reality" at the level of visual perception. Modeling of higher-level knowledge is likewise unavoidable and often equally unconscious. Figure 4 shows a

mental model elicited during a meeting between my colleague, Fred Kofman, and a team from a large global corporation. The company worked with the Organizational Learning Center at MIT to explore ways to reduce the total cycle time for its supply chain. At the time, the cycle time was 182 days, and the company sought to reduce that by half, to 90 days. It viewed the reduction as essential for continued competitiveness and even corporate survival. With the support of senior management, it assembled a team to address these issues. At the first meeting, the team presented background information, including figure 4. The figure shows the current cycle time divided into three intervals along a line representing: manufacturing, order fulfillment, and customer acceptance lead times. Order fulfillment, which then required 22 days, occupies more than half of the total length of the line, while the manufacturing lead time, then requiring 75 days (70 days due to suppliers), receives about one quarter of the length. Customer acceptance, then requiring 85 days, occupies only about one eighth of the total length. The figure reveals the prominence of order fulfillment operations in the mental models of the people on the team, and the insignificance in their minds of vendors and customers. It will come as no surprise to the reader that all of the members of the team worked in functions contributing to order fulfillment. Not one represented procurement, or a supplier, or accounting, or a customer. Until Fred pointed out this distortion, the members of the group were as unaware of the illusory character of their image of the supply line as we normally are of the illusory contours we project onto the sense data transmitted by our optic nerves. The distorted mental model of the supply chain significantly constrained the company's ability to achieve cycle time reduction: even if order fulfillment could be accomplished instantly, the organization would fall well short of its cycle time goal.

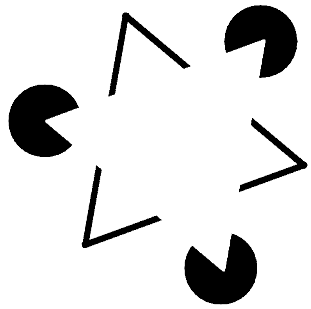

Figure 3. Kanizsa triangle.

Figure 5 illustrates the type of reframing that Fred's intervention stimulated, denoted "double-loop learning" by Argyris (1985). Here information feedback about the real world not only alters our decisions within the context of existing frames and decision rules, but also feeds back to alter our mental models. As our mental models change, we create different decision rules and change the strategy and structure of our organizations. The same information, filtered and processed through a different decision rule, now yields a different decision. The development of systems thinking is a double-loop learning process in which we replace a reductionist, partial, narrow, short-term view of the world with a holistic, broad, long-term, dynamic view—and then redesign our policies and institutions accordingly.

Barriers to Learning

For learning to occur, each link in the two feedback loops must work effectively, and we must be able to cycle around the loops quickly relative to the rate at which changes in the real world render existing knowledge obsolete. Yet in the real world, particularly the world of social action, these feedbacks often do not operate well. Figure 6 shows the main ways in which each link in the learning feedbacks can fail. These include dynamic complexity, imperfect information about the state of the real world, confounding and ambiguous variables, poor scientific reasoning skills, defensive routines and other barriers to

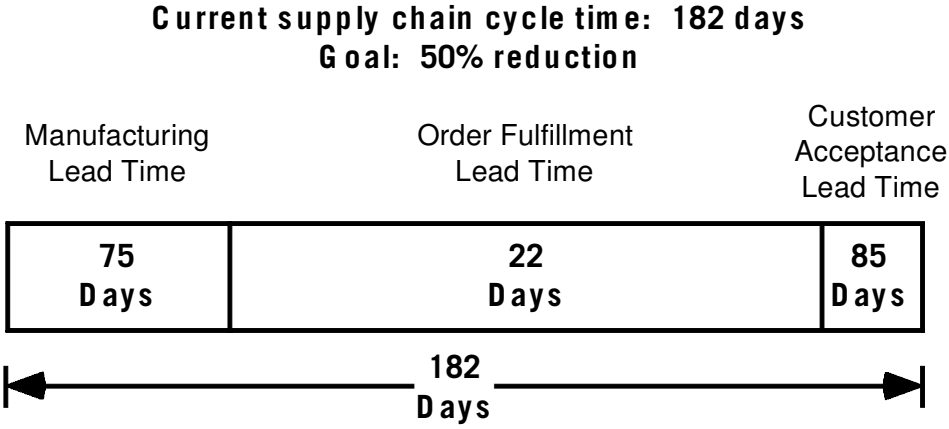

Figure 4. Diagram of a company's supply chain. Note that the time intervals do not map onto the lengths of the segments representing those intervals. The corporate goal was to reduce the duration of the supply chain by half, to roughly 90 days. The figure has been simplified to protect confidential information, but drawn to scale.

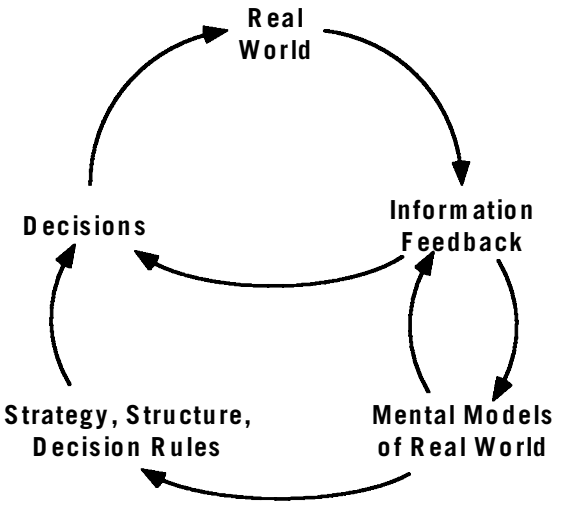

Figure 5. Feedback from the real world can also cause changes in mental models. Such learning involves new articulations of our understanding, or reframing of a situation, and leads to new goals and new decision rules, not just new decisions.

effective group processes, implementation failure, and the misperceptions of feedback that limit our ability to understand the structure and dynamics of complex systems.

Dynamic Complexity

Much of the literature in psychology and other fields suggests that learning proceeds via the simple negative feedback loops described in figure 5. Implicitly, the loops are seen as first-order, linear negative feedbacks that produce stable convergence to an equilibrium or optimal outcome. But the real world is not so simple. From the beginning, system dynamics emphasized the multi-loop, multi-state, nonlinear character of the feedback systems in which we live (Forrester, 1961). The decisions of any one agent form but one of many feedback loops that operate in any given system. These loops may reflect both anticipated and unanticipated side effects of the decision maker's actions, there may be positive as well as negative feedback loops, and these loops will contain many stocks (state variables) and many nonlinearities. Natural and human systems have high levels of *dynamic complexity*.

Time delays between taking a decision and the decision's effects on the state of the system are common and particularly problematic. Most obviously, delays reduce the number of times one can cycle around the learning loop, slowing the ability to accumulate experience, test hypotheses, and improve. Schneiderman (1988) estimated the improvement half life—the time required to cut defects in half—in a wide range of manufacturing firms. He found improvement half lives as short as a few months for processes with short delays—for example, reducing operator error in a job shop—while complex processes with long time delays such as product development had improvement half lives of several years or more (Sterman, Repenning, and Kofman, 1997, show how these differential improvement rates led to difficulty at a leading semiconductor manufacturer).

Dynamic complexity not only slows the learning loop, it also reduces the learning gained on each cycle. In many cases, controlled experiments are prohibitively costly or unethical. More often, controlled experiments are simply impossible to conduct. Complex systems are in disequilibrium and evolve. Many actions yield irreversible consequences. The past cannot be compared well to current circumstance. The existence of multiple interacting feedbacks means that it is difficult to hold other aspects of the system constant to isolate the effect of the variable of interest. As a result, many variables simultaneously change, confounding the interpretation of changes in system behavior (see below), and reducing the effectiveness of each cycle around the learning loop.

Delays also create instability in dynamic systems. Adding time delays to the negative feedback loops increases the tendency for the system to oscillate.[5] Systems, from driving a car to drinking alcohol to raising hogs to construction of office buildings, all involve time delays between the initiation of a control action (accelerating/braking, deciding to "have another," choosing to breed more hogs, initiating development of a new building) and its effects on the state of the system. As a result, decision makers often continue to intervene to correct apparent discrepancies between the desired and actual state of the system even after sufficient corrective actions have been taken to restore the system to equilibrium, leading to overshoot and oscillation. The result is stop-and-go traffic, drunkenness, commodity cycles, and real estate boom-and-bust cycles (see Sterman, 1989a, for discussion). Oscillation and instability reduce our ability to control for confounding variables and to discern cause and effect, further slowing the rate of learning.

Limited Information

We experience the real world through filters. Managers do not know the current sales rate of their firm, its current rate of production, or the true value of its order backlog. Instead, we receive estimates of these data based on sampled, averaged, and delayed measurements. The act of measurement introduces distortions, delays, biases, errors, and other im-

perfections, some known, others unknown and unknowable. Above all, measurement is an act of selection. Our senses and information systems select but a tiny fraction of possible experience. Some of the selection is "hard-wired" (we cannot see in the infrared or hear ultrasound). Some results from our own decisions. We define Gross Domestic Product (GDP) so that extraction of non-renewable resources counts as production of "goods" rather than depletion of natural capital stocks, and so that medical care to treat pollution-induced disease is counted as goods and services that add to GDP, while the production of the pollution itself does not reduce it. Because the prices of most goods in our economic system do not include the costs of resource depletion or waste disposal, these "externalities" receive little weight in decision making (see Cobb and Daly, 1989, for thoughtful discussion of alternative measures of economic welfare).

Of course, the information systems governing the feedback we receive and its characteristics can change as we learn. They are part of the feedback structure of our systems. Through our mental models, we define constructs such as "GDP" or "scientific research," create metrics for these constructs, and design information systems to evaluate and report them. These then condition the perceptions we form. Changes in our mental models are constrained by what we previously chose to define, measure, and attend to. Seeing is believing *and* believing is seeing.[6]

In a famous experiment, Bruner and Postman (1949) showed playing cards to people using a tachistoscope to control exposure time to the stimuli. Most subjects could identify the cards rapidly and accurately. The researchers also showed subjects anomalous cards, such as a black three of hearts, or a red ten of spades. Subjects took on average four times as long to judge the anomalous cards. Many misidentified them (e.g., they said "three of spades" or "three of hearts" when shown a black three of hearts). Some could not identify

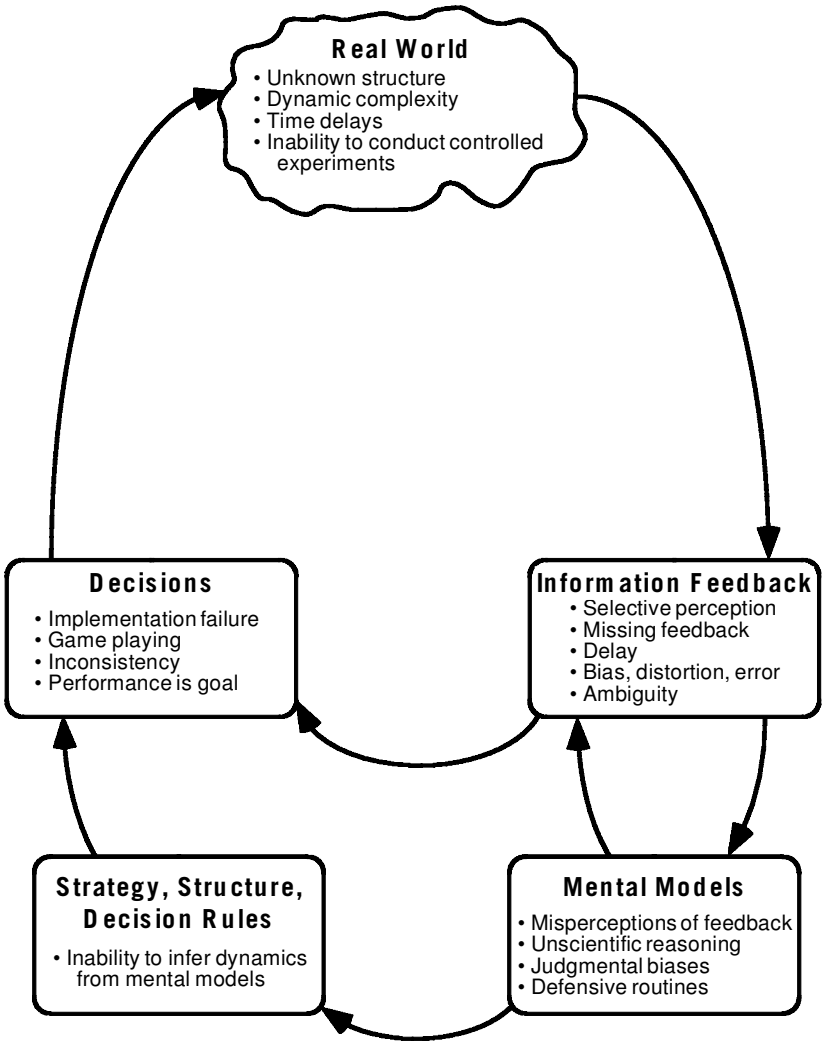

Figure 6. Impediments to learning.

the card at all, even with very long exposure times, and grew anxious and confused. Only a small minority correctly identified the cards. Bruner and Postman concluded that, "Perceptual organization is powerfully determined by expectations built upon past commerce with the environment." The self-reinforcing feedback between expectations and perceptions has been repeatedly demonstrated in a wide variety of experimental studies (see Plous, 1993, for excellent discussion). Sometimes the positive feedback assists learning by sharpening our ability to perceive features of the environment, as when an experienced naturalist identifies a bird in a distant bush where the novice birder sees only a tangled thicket. Often, however, the mutual feedback of expectations and perception limits learning by blinding us to the anomalies that might challenge our mental models. Thomas Kuhn (1970) cited the Bruner-Postman study to argue that a scientific paradigm suppresses the perception of data inconsistent with the paradigm, making it hard for scientists to perceive anomalies that might lead to scientific revolution. Sterman (1985) developed a formal model of Kuhn's theory, which showed that the positive feedback between expectations and perceptions suppressed the recognition of anomalies and the emergence of new paradigms.

Changes in our mental models are constrained by what we previously chose to define, measure, and attend to. Seeing is believing and believing is seeing.

Two recent cases, one a global environmental issue and the other the fight against AIDS, show that the mutual dependence of expectation and perception is not a laboratory artifact but a phenomenon with potentially grave consequences for humanity.

The first scientific papers describing the ability of chlorofluorocarbons (CFCs) to destroy atmospheric ozone were published in 1974 (Stolarski and Cicerone, 1974; Molina and Rowland, 1974). Yet much of the scientific community remained skeptical, and despite a ban on CFCs as aerosol propellants, global production of CFCs remained near its all-time high. It was not until 1985 that evidence of a deep "ozone hole" in the Antarctica was published (Farman, Gardiner, and Shanklin, 1985). As described by Meadows, Meadows, and Randers (1992, pp.151–152):

> The news reverberated around the scientific world. Scientists at [NASA]. . . scrambled to check readings on atmospheric ozone made by the Nimbus 7 satellite, measurements that had been taken routinely since 1978. Nimbus 7 had never indicated an ozone hole.
>
> Checking back, NASA scientists found that their computers had been programmed to reject very low ozone readings on the assumption that such low readings must indicate instrument error.

The NASA scientists' belief that low ozone readings must be erroneous led them to design a measurement system that made it impossible to detect low readings that might have invalidated their models. Fortunately, NASA had saved the original, unfiltered data and later confirmed that total ozone had indeed been falling since the launch of Nimbus 7. Because NASA created a measurement system immune to disconfirmation, the discovery of the ozone hole and resulting global agreements to cease CFC production were delayed by as much as seven years. Those seven years could be significant: ozone levels in Antarctica dropped to less than one third of normal in 1993, and current models show atmospheric chlorine will not begin to fall until after the year 2000, and then only slowly. Recent measurements show that thinning of the ozone layer is a global phenomenon, not just a problem for penguins. Measurements taken near Toronto show a 5% increase in cancer-causing UV-B ultraviolet radiation at ground level: ozone depletion now affects the agriculturally important and heavily populated Northern hemisphere [7]

The second example comes from the fight against AIDS. Until recently, AIDS vaccine research was dominated by the search for "sterilizing immunity"—a vaccine that could prevent a person from becoming infected with HIV altogether, rather than "merely" preventing disease. Potential vaccines are administered to monkeys, who are then challenged with SIV, the simian analog of HIV. The blood and lymph systems of the monkeys are then tested to see if they become infected. Despite early promise, the candidate vaccines tried so far have failed: the vaccinated monkeys became infected at about the same rate as the unvaccinated controls. As each trial vaccine failed, researchers moved on to other candidates. The experimenters often killed the monkeys from the

failed trial to free up lab space for the next trial. A few researchers, however, continued observing their monkeys. They were surprised to find that even though their vaccine did not prevent infection, the vaccinated monkeys survived longer, were healthier, and had lower concentrations of virus in their blood than the controls. These results are stimulating interest in a model of disease prevention rather than prevention of infection. However, evaluation of, and thus resources to support work in the new approach have been delayed because so many of the monkeys that received trial vaccinations were killed after blood tests revealed they had become infected, denying the researchers the opportunity to observe whether the vaccine helped prevent AIDS. Patricia Fast, a researcher with the U.S. National Institute on AIDS, lamented that, "A lot of monkeys have been killed because it seemed like the experiment was over. . . . In retrospect, we wish we would have kept them alive" (quoted in Cohen, 1993). Just as NASA's belief that ozone concentrations could not be low prevented NASA scientists from learning that ozone concentrations were low, the belief that only sterilizing immunity could stop AIDS prevented researchers from discovering another promising therapy as early as they might have.[8]

Confounding Variables and Ambiguity

To learn, we must use the limited and imperfect feedback available to us to understand the effects of our own decisions, so that we can adjust our decisions to align the state of the system with our goals (single-loop learning), and so we can revise our mental models and redesign the system itself (double-loop learning). Yet much of the outcome feedback we receive is ambiguous. Ambiguity arises because changes in the state of the system resulting from our own decisions are confounded with simultaneous changes in a host of other variables, both exogenous and endogenous. The number of variables that might affect the system vastly overwhelms the data available to rule out alternative theories and competing interpretations. This "identification problem" plagues both qualitative and quantitative approaches. In the qualitative realm, ambiguity arises from the ability of language to support multiple meanings. In the opening soliloquy of *Richard III*, the hump-backed Richard laments his deformity:

> And therefore, since I cannot prove a lover
> To entertain these fair well-spoken days,
> I am determinèd to prove a villain
> And hate the idle pleasures of these days.
> (I, i, 28–31)

Does Richard celebrate his free choice to be evil, or resign himself to a predestined fate? Did Shakespeare intend the double meaning? Rich, ambiguous texts, with multiple layers of meaning, often make for beautiful and profound art, along with employment for literary critics, but also make it hard to know the minds of others, rule out competing hypotheses, and evaluate the impact of our past actions so we can decide how to act in the future.

In the quantitative realm, econometricians have long struggled with the problem of uniquely identifying the structure and parameters of a system from its observed behavior. Elegant and sophisticated theory exists to delimit the conditions in which one can identify a system. In practice, the data are too scarce, and the plausible alternative specifications too numerous, for econometric methods to discriminate among competing theories. The same data often support wildly divergent models equally well, and conclusions based on such models are not robust. As Leamer (1983) put it in an article entitled "Let's take the con out of econometrics:"

> In order to draw inferences from data as described by econometric texts, it is necessary to make whimsical assumptions. . . . The haphazard way we individually and collectively study the fragility of inferences leaves most of us unconvinced that any inference is believable.[9]

Misperceptions of Feedback

Effective management is difficult in a world of high dynamic complexity. Our decisions may create unanticipated side effects and delayed consequences. Our attempts to stabi-

lize the system may destabilize it. Our decisions may provoke reactions by other agents seeking to restore the balance we upset. Our decisions may move the system into a new regime of behavior where unexpected and unfamiliar dynamics arise because the dominant feedback loops have changed. Forrester (1971) calls such phenomena the "counterintuitive behavior of social systems." It often leads to "policy resistance," the tendency for interventions to be delayed, diluted, or defeated by the response of the system to the intervention itself (Meadows, 1982). No less an organizational theorist than Machiavelli discussed policy resistance at length, observing in the *Discourses* that:

Effective management is difficult in a world of high dynamic complexity. Our decisions may create unanticipated side effects and delayed consequences.

> When a problem arises either from within a republic or outside it, one brought about either by internal or external reasons, one that has become so great that it begins to make everyone afraid, the safest policy is to delay dealing with it rather than trying to do away with it, because those who try to do away with it almost always increase its strength and accelerate the harm which they feared might come from it. (Machiavelli, 1979, pp. 240–241).

Recent experimental studies confirm these observations. Human performance in complex dynamic environments is poor relative to normative standards, and poor even compared to simple decision rules.

- Subjects, including experienced managers, in a simple production-distribution system (the Beer Distribution Game) generate costly fluctuations, even when consumer demand is constant. Average costs are more than 10 times greater than optimal (Sterman, 1989b).
- Subjects responsible for capital investment in a simple multiplier-accelerator model of the economy generate large amplitude cycles even though consumer demand is constant. Average costs are more than 30 times greater than optimal (Sterman, 1989a).
- Subjects managing a firm in a simulated consumer product market generate the boom-and-bust, price war, and shake-out characteristic of industries from video games to chain saws (Paich and Sterman, 1993).
- Participants in experimental asset markets repeatedly bid prices well above fundamental value, only to see them plummet when a "greater fool" can no longer be found to buy. These speculative bubbles do not disappear when the participants are investment professionals, when monetary incentives are provided, or when short-selling is allowed (Smith, Suchanek, and Williams, 1988).
- In a simulation of a forest fire, many people allow their headquarters to burn down despite their best efforts to put out the fire (Brehmer, 1989).
- In a medical setting, subjects playing the role of doctors order more tests while the (simulated) patients sicken and die (Kleinmuntz and Thomas, 1987).

These studies and many others (Brehmer, 1992, provides a recent review; Funke, 1991, reviews the large literature of the "German School" led by Dörner, Funke, and colleagues) show that performance is far from optimal—often far from reasonable—in a wide range of tasks, from managing an ecosystem to governing a town or controlling a factory.

In the "Beer Distribution Game," for example, subjects seek to minimize costs as they manage the production and distribution of a commodity (Sterman, 1989b, 1992). Though simplified compared to real firms, the task is dynamically complex because it includes multiple feedbacks, time delays, nonlinearities, and accumulations. Average costs were 10 times greater than optimal. The subjects generated costly oscillations with consistent amplitude and phase relations, even though demand was essentially constant. Econometric analysis of subjects' decisions showed that people were insensitive to the time delays in the system. They did not account well, and often not at all, for the supply line of orders that had been placed but not yet received, which caused them to overcompensate for inventory shortfalls. Facing an inventory shortfall, many subjects order enough beer to close the gap. Because of the delay in filling orders, inventory remains depressed, and the next period they order more beer. Still deliveries are insufficient, and they order the needed beer again. Finally, the first order arrives, inventory rises to the desired level, and the subjects cut their orders. But the beer in the supply line continues to arrive, swelling

their inventory many times above the desired levels—and causing emotional reactions from anxiety to anger to chagrin. Significantly, subjects often blame their difficulty on exogenous events. When asked to sketch the pattern of customer demand, for example, most draw a large amplitude fluctuation similar to the oscillation they generated. When it is revealed that customer demand was in fact constant, many voice disbelief.

In a second experiment (Sterman, 1989a), subjects exhibited the same behavior in a simulated macroeconomy representing the capital investment multiplier/accelerator. Analysis of the subjects' decision rules showed they used essentially the same rule as subjects in the Beer Distribution Game. The estimated parameters again showed most people ignored the time delays and feedback structure of the task, even though each subject was the only decision maker and the structure was completely revealed.

Simulation of the decision rules estimated for the subjects in both experiments showed that approximately one-third were intrinsically unstable, so that the system never reached equilibrium. About one-quarter of the estimated rules yield deterministic chaos (Sterman, 1988, 1989c). The heuristics people used interacted with the feedback structure of these systems to yield severe, persistent, and costly oscillations.

These studies led me to suggest that the observed dysfunction in dynamically complex settings arises from "misperceptions of feedback." I argued that the mental models people use to guide their decisions are dynamically deficient. Specifically, people generally adopt an event-based, "open-loop" view of causality, ignore feedback processes, fail to appreciate time delays between action and response, and in the reporting of information, do not understand stocks and flows, and are insensitive to nonlinearities that may alter the strengths of different feedback loops as a system evolves.

Subsequent experiments show that the greater the dynamic complexity of the environment, the worse people do *relative to potential.* Diehl and Sterman (1995) examined the performance of MIT undergraduates in a simple, one-person inventory management task. Time delays and side-effect feedbacks were varied from trial to trial as experimental treatments. We compared subject performance against two benchmarks: optimal behavior, and the behavior of a "do-nothing" rule. The results strongly supported the misperceptions of feedback hypothesis. Overall, subject costs were more than four times greater than optimal, despite financial incentives, training, and repeated play. In the easy conditions (no time delays or feedback effects), subjects dramatically outperformed the "do-nothing" rule, but in the difficult conditions, many were bested by the "do-nothing" rule, that is, their attempts to control the system were counterproductive. Regression models of subject decision rules showed little evidence that subjects adapted their decision rules as the complexity of the task changed. Indeed, when the environment was complex, subjects seemed to revert to simple rules that ignored the time delays and feedbacks, leading to degraded performance. There was no significant difference in the time taken to make decisions across the different complexity levels, even though the number of variables to consider is much greater in the difficult conditions.

Paich and Sterman (1993) showed that learning in situations of dynamic complexity is often poor. We designed a management flight simulator representing a common and realistic corporate strategy setting.[10] The simulation portrays the market for a consumer durable product that the subjects manage through the full product life cycle, from launch through decline. The simulation includes realistic features of such markets, including price elasticity effects, marketing, word-of-mouth, original and replacement demand, competition, learning curves, and capacity acquisition delays. Subjects make price and capacity expansion decisions each quarter for 10 simulated years. They played five such trials, each with different characteristics of the market and product. As treatments, we varied the strength of the key feedback loops in the simulated market. Results show patterns characteristic of many real consumer durable markets, including boom-and-bust, overcapacity, price war, and shakeout. We contrast subject performance against a simple decision rule

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embodying a naive strategy. The naive strategy does not engage in any strategic or game theoretic reasoning. Indeed, it is insensitive to the feedback structure of the market and the behavior of the competitor. Yet the naive strategy outperforms nearly 90% of the subjects. Performance *relative to potential* is degraded significantly as the feedback complexity of the environment grows, consistent with the misperceptions of feedback hypothesis.

Though subjects improved with experience, they learned little, despite an accumulated 50 years of simulated experience in an environment with perfect, immediate outcome feedback. Yet in the last trial, the naive strategy still outperformed 83% of the subjects. Most important, they did not learn how to improve their performance in the dynamically complex conditions. Even in the last trial, the stronger the feedback complexity of the environment, the lower profits were relative to potential. The degradation of performance relative to potential caused by high feedback complexity is not moderated by experience. Estimation of subject decision rules showed subjects actually became less responsive to critical variables and more vulnerable to forecasting errors—their learning hurt their ability to perform well in the complex conditions.

Other experiments show that the misperceptions of feedback are robust to experience, incentives, opportunities for learning, and the presence of market institutions. Kampmann and Sterman (1994) designed an experiment where subjects managed a firm in an experimental economy under various market institutions and feedback complexity conditions. The high feedback complexity condition included production delays and a multiplier feedback from production to aggregate demand; the simple condition had neither. Three market institutions were tested: fixed prices, posted prices, and market clearing prices. Subjects were mostly MIT and Harvard graduate students in economics, and were paid in proportion to their profits in the experiment.

In the constant price, dynamically complex condition subjects created the same unstable fluctuations observed in the experiments discussed above. In the simple, market-clearing condition with no feedback complexity, subjects generally converged to the predicted equilibrium, replicating prior studies in experimental economics.

However, performance *relative to optimal* in all three price institutions was significantly worse in the complex condition than the simple one. Even in perfectly functioning markets, modest levels of dynamic complexity caused large and systematic deviations from rational behavior. Complexity reduced subjects' ability to reach and maintain the cooperative equilibrium, slowed learning, and reduced the consistency of decisions. In the complex conditions, most subjects created sustained "business cycles," even though the environment was unchanging. As in the Beer Game, they attributed these cycles to exogenous changes in consumer demand.

Process data and regression models of subject decisions showed that people used only a few cues, tended to ignore time delays and feedbacks, and forecasted by averaging past values and extrapolating past trends. Subjects actually spent less time making their decisions in the complex markets than in the simple markets. Simulations of the estimated rules replicated the aggregate dynamics of the experimental markets with surprising fidelity. Thus while markets may reduce the magnitude of errors caused by the misperceptions of feedback, they do not eliminate them. Even well-functioning markets do not render the bounds on human rationality irrelevant.

We are unable to infer correctly the dynamics of all but the simplest causal maps.

The robustness of the misperceptions of feedback, and the poor performance they lead us to create across many domains, are due to two basic and related deficiencies in our mental models of complexity. First, our cognitive maps of the causal structure of systems are vastly simplified compared to the complexity of the systems themselves. Second, we are unable to infer correctly the dynamics of all but the simplest causal maps. Both deficiencies are direct consequences of bounded rationality (Simon, 1979, 1982); that is, the many limitations of attention, memory, recall, information processing, and time that constrain human decision making.

Flawed Cognitive Maps of Causal Relations

Causal attributions are a central feature of mental models. People create, update, and maintain cognitive maps of causal connections among entities and actors, from the prosaic—"if

I touch a flame I will be burned"—to the grand—"the larger the government deficit, the higher interest rates will be." Studies of cognitive maps show that few incorporate any feedback loops. Axelrod (1976) found virtually no feedback processes in studies of the cognitive maps of political elites. Rather, people tended to formulate intuitive decision trees relating possible actions to probable consequences—event-level representations. Hall (1976) reports similar open-loop mental maps in a study of the publishing industry. Dörner (1980) found that people tend to think in single-strand causal series, and have difficulty in systems with side effects and multiple causal pathways (much less feedback loops). Similarly, experiments in causal attribution show that people tend to assume each effect has a single cause and often cease their search for explanations when a sufficient cause is found; base rates and situational factors are usually ignored (see the discussion in Plous, 1993).

The heuristics we use to judge causal relations lead systematically to cognitive maps that ignore feedbacks, multiple interconnections, nonlinearities, time delays, and the other elements of dynamic complexity. The "causal field," or mental model of the stage on which the action occurs, is crucial in framing people's judgments of causation (Einhorn and Hogarth, 1986). Within a causal field, people use various "cues to causality," including temporal and spatial proximity of cause and effect, temporal precedence of causes, covariation, and similarity of cause and effect. These heuristics lead to difficulty in complex systems where cause and effect are often distant in time and space, actions have multiple effects, and the delayed and distant consequences can be different from and less salient than proximate effects—or simply unknown.

The multiple feedbacks in complex systems cause many variables to be correlated with one another, confounding the task of judging cause. However, people are poor judges of correlation. In the widely studied "multiple cue probability learning" paradigm, subjects seek to discover the relationship between a criterion and various cues upon which it depends (along with a random error) by predicting the criterion from the cues and then receiving outcome feedback on the accuracy of their judgment. Given enough trials, people can generally detect linear, positive correlations—if the outcome feedback is accurate enough. However, they have great difficulty in the presence of random error, nonlinearity, and negative correlations, often never discovering the true relationship (Brehmer, 1980).

A fundamental principle of system dynamics states that the structure of the system gives rise to its behavior. However, people have a strong tendency to attribute the behavior of others to dispositional rather than situational factors—the so-called "fundamental attribution error" (see Ross, 1977). In complex systems, the same policy (decision rule) can lead to very different behavior (decisions) as the state of the system changes. When we attribute differences in behavior to differences in personality, we lose sight of the role of system structure in shaping our choices. The attribution of behavior to individuals and special circumstances rather than to system structure systematically diverts our attention from the high leverage points where redesign of the system or governing policy can have significant, sustained, and beneficial effects on performance (Forrester, 1969, chapter 6; Meadows, 1982). When we attribute behavior to people rather than system structure, the focus of management becomes the search for extraordinary people to do the job rather than designing the job so that ordinary people can do it.

Erroneous Inferences about Dynamics

Even if our cognitive maps of causal structure were perfect, learning, especially double-loop learning, would still be difficult. In order to use a mental model to design a new strategy or organization, we must make inferences about the consequences of decision rules that have never been tried and for which we have no data. To do so requires intuitive solution of high-order nonlinear differential equations, a task far exceeding human cognitive capabilities in all but the simplest systems (Forrester, 1971; Simon, 1982). In several of the experiments discussed earlier, including the inventory management task in Diehl and Sterman (1995) and the multiplier-accelerator task in Sterman (1989a), subjects received complete knowledge of all structural relationships and parameters, along with perfect, comprehensive, and immediate outcome feedback. The subjects were the only players. Further, the systems were simple enough that the number of cues to consider was small—the multiplier-accelerator task involved only three stated variables. Poor

performance in these tasks seems to be due to the inability of the subjects to use their perfect knowledge to make reasonable inferences about the dynamics of the system or its response to possible decisions they might make.

People cannot simulate mentally even the simplest possible feedback system, the first-order linear positive feedback loop. The differential equation, $dx/dt = gx$, yields pure exponential growth, $x = x_o exp(gt)$. Such positive feedback processes are commonplace, from the compounding of interest to the growth of populations. Wagenaar and Sagaria (1975) and Wagenaar and Timmers (1978, 1979) showed that people significantly underestimate exponential growth, tending to extrapolate linearly rather than exponentially. Using more data points or graphing the data did not help, and mathematical training did not improve performance.

When we attribute behavior to people rather than system structure, the focus of management becomes the search for extraordinary people to do the job rather than designing the job so that ordinary people can do it.

Thus, bounded rationality simultaneously constrains the complexity of our cognitive maps and our ability to use them to anticipate the system dynamics. Schemata where the world is seen as a sequence of events and where feedback, nonlinearity, time delays, and multiple consequences are lacking lead to poor performance in settings where these elements of dynamic complexity are prevalent. Dysfunction in complex systems can arise from the misperception of the feedback *structure* of the environment. But schemata that do account for complexity cannot be used reliably to understand the dynamics. Dysfunction in complex systems can arise from faulty mental simulation—the misperception of feedback *dynamics*. For effective learning to occur, both of these bounds on rationality must be overcome. Perfect maps without a simulation capability yield little insight; a calculus for reliable inferences about dynamics yields systematically erroneous results when applied to simplistic maps.

Unscientific Reasoning; Judgmental Errors and Biases

To learn effectively in a world of dynamic complexity and imperfect information, people must develop what Davis and Hogarth (1992) call "insight skills"—the skills that help people learn when feedback is ambiguous:

> [T]he interpretation of feedback in the form of outcomes needs to be an *active* and *disciplined* task governed by the rigorous rules of scientific inference. Beliefs must be actively challenged by seeking possible disconfirming evidence and asking whether alternative beliefs could not account for the facts [emphasis in original].

Unfortunately, people are poor intuitive scientists, generally failing to reason in accordance with the principles of scientific method. For example, people do not generate sufficient alternative explanations, or consider enough rival hypotheses. People generally do not adequately control for confounding variables when they explore a novel environment. Their judgments are strongly affected by the frame in which the information is presented, even when the objective information is unchanged. They suffer from overconfidence in their judgments (underestimating uncertainty), wishful thinking (assessing desired outcomes as more likely than undesired outcomes), and the illusion of control (believing one can predict or influence the outcome of random events). People violate basic rules of probability, believe in the "law of small numbers," do not understand basic statistical concepts such as regression to the mean, and do not update beliefs according to Bayes's rule. Hindsight, the availability and salience of examples, and the desirability of outcomes distort memory. And so on. Hogarth (1987) discusses 30 different biases and errors documented in decision-making research, and provides a good guide to the literature (see also Kahneman, Slovic, and Tversky, 1982). The research convincingly shows that scientists and professionals, not only "ordinary" people, suffer from many of these judgmental biases.

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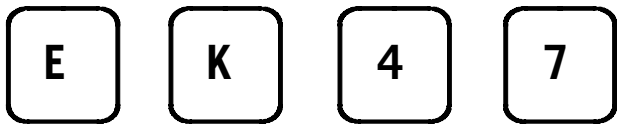

Figure 7. Wason card task. What is the smallest number of cards you should turn over to test the rule that "cards with vowels on one side have even numbers on the reverse," and which are they?

Among the failures of scientific reasoning most inimical to learning is the tendency to seek evidence consistent with current beliefs rather than potential disconfirmation (Einhorn and Hogarth, 1978; Klayman and Ha, 1987). In a famous series of experiments, Wason and colleagues presented people with tasks of the sort shown in figure 7.[11] In one version, you are shown one side of four cards, each with a letter on one side and a number on the other, say, E, K, 4, and 7. You are told that, "If a card has a vowel on one side, then it has an even number on the other side." You must then identify the smallest set of cards to turn over to see if the proposed rule is correct. Wason and Johnson-Laird (1972) found that the vast majority of subjects selected E, or E and 4, as the answers. Less than 4% gave the correct answer, E and 7. The rule has the logical form, "if p then q." Falsification requires observation of "p and not-q." The only card showing "p" is the E card, so it must be examined—the back of the E card must be an even number if the rule holds. The only card showing "not-q" is the 7, so it must be examined. The K and 4 cards are irrelevant. Yet people consistently choose the card showing "q," a choice that can only provide data consistent with the theory, but cannot test it—if the back of the 4 is a consonant, you have learned nothing, since the rule is silent about the numbers associated with consonants. Experiments show the tendency to seek confirmation is robust in the face of training in logic, mathematics, and statistics. Search strategies that focus only on confirmation of current beliefs slow the generation and recognition of anomalies that might lead to learning, particularly double-loop learning (see also Davis and Hogarth, 1992, for examples and discussion).

Some argue that while people err in applying the principles of logic, at least they are rational in the sense that they appreciate the desirability of scientific explanation. Unfortunately, the situation is far worse. The rational, scientific world view is a relatively recent development in human history and remains rare. Many people place their faith in what Dostoyevsky's Grand Inquisitor called "miracle, mystery, and authority"—for example, astrology, ESP, UFOs, creationism, conspiracy theories of history, channeling of past lives, cult leaders promising Armageddon, and Elvis sightings. The persistence of such superstitious beliefs depends partly on the bias towards confirming evidence. Wade Boggs, the former Red Sox batting champion, ate chicken every day for years because he once had a particularly good day at the plate after a dinner of lemon chicken (Shaughnessy, 1987). During this time, Boggs won five batting championships, "proving" the wisdom of the "chicken theory." Consider the continued popularity of astrology, psychics, and economic forecasters, who publicize their "successes" and suppress their (more numerous) failures. Remember that less than a decade ago, the President of the United States and the First Lady managed affairs of state on the basis of astrology (Robinson, 1988). And it worked: he was reelected in a landslide.

Among the failures of scientific reasoning most inimical to learning is the tendency to seek evidence consistent with current beliefs rather than potential disconfirmation.

Such lunacy aside, there are deeper and more disturbing reasons for the prevalence of these learning failures and the superstitions they engender. Human beings are more than cognitive information processors. We have a deep need for emotional and spiritual sustenance. But from Copernican heliocentrism through evolution, relativity, quantum mechanics, and Gödelian uncertainty, science stripped away ancient and comforting structures that placed humanity at the center of a rational universe designed for us by a supreme authority. For many people, scientific thought leads not to enlightenment but to existential angst and the absurdity of human insignificance in an incomprehensibly vast universe. For other people, science and technology were the shock troops for the triumph of materialism and instrumentalism over the sacred and spiritual. These anti-scientific reactions are powerful forces. In many ways, they are important truths. They have led to many of the most profound works of art and literature. But they can also lead to mindless new-age psychobabble.

The reader should not be lulled into concluding that I am a naive defender of science as it is practiced, or an apologist for the real and continuing damage done to the

environment and to our cultural, moral, and spiritual lives in the name of rationality and progress. On the contrary, I have stressed the research showing that scientists are often as prone to the judgmental errors and biases discussed above as lay people. It is precisely because scientists are subject to the same cognitive limitations and moral failures as others that we experience abominations such as the U.S. government-funded research in which plutonium was injected into seriously ill patients, and in which radioactive calcium was fed to retarded children, all without their knowledge or consent (Mann, 1994). A central principle of the systems view of the world is to examine issues from multiple perspectives, and to expand the boundaries of our mental models to consider the long-term consequences and "side effects" of our actions, including their environmental, cultural, and moral implications (Meadows, Richardson, and Bruckmann, 1982).

Defensive Routines and Interpersonal Impediments to Learning

Learning by groups can be thwarted even if the system provides excellent information feedback and the decision makers reason well as individuals. We rely on our mental models to interpret the language and acts of others, construct meaning, and infer motives. However, as Forrester (1971) argues:

> The mental model is fuzzy. It is incomplete. It is imprecisely stated. Furthermore, within one individual, a mental model changes with time and even during the flow of a single conversation. The human mind assembles a few relationships to fit the context of a discussion. As the subject shifts so does the model. . . . [E]ach participant in a conversation employs a different mental model to interpret the subject. Fundamental assumptions differ but are never brought into the open.

Argyris (1985), Argyris and Schön (1978), Janis (1982), Schein (1969, 1985, 1987), and others document the defensive routines and cultural assumptions that people rely on, often unknowingly, to interact with and interpret their experience of others. We use defensive routines to save face, assert dominance over others, make untested inferences seem like facts, and advocate our positions while appearing to be neutral. We make conflicting, unstated attributions about the data we receive, and fail to distinguish between the sense-data of experience and the attributions and generalizations we readily form from them. We avoid testing our hypotheses and beliefs publicly, and avoid threatening issues. Above all, defensive behavior involves covering up the defensiveness and making these issues undiscussable, even when all parties are aware they exist.

Defensive routines are subtle. They often arrive cloaked in apparent concern and respect for others. Consider the strategy of "easing-in":

> If you are about to criticize someone who might become defensive and you want him to see the point without undue resistance, do not state the criticism openly; instead, ask questions such that if he answers them correctly, he will figure out what you are not saying (Argyris, Putnam, and Smith, 1985, p. 83).

But easing-in often

> creates the very defensiveness that it is intended to avoid, because the recipient typically understands that the actor is easing-in. Indeed, easing-in can be successful only if the recipient understands that he is supposed to answer the questions in a particular way, and this entails the understanding that the actor is negatively evaluating the recipient and acting as if this were not the case (Argyris, Putnam, and Smith, 1985, p. 85).

Defensive behavior, in which the "espoused theories" we offer to others differ from our "theories in use," prevents learning by hiding important information from others, avoiding public testing of important hypotheses, and tacitly communicating that we are not open to having our mental models challenged. Defensive routines often yield "groupthink" (Janis, 1982), where members of a group mutually reinforce their current beliefs, suppress dissent, and seal themselves off from those with different views or possible disconfirming evidence. Defensive routines ensure that the mental models of team members remain hidden, ill-formed, and ambiguous. Thus, learning by groups can suffer even beyond the impediments to individual learning.

Implementation Failure

In the real world, decisions are often implemented imperfectly, further hindering learning. Even if a team agrees on the proper course of action, the implementation of these decisions can be delayed and distorted as the organization responds. Local incentives, asymmetric information, and private agendas can lead to game playing by agents throughout a system. Obviously, implementation failures can hurt the organization. Imperfect implementation can defeat the learning process as well, because the management team evaluating the outcomes of its decisions may not know the ways in which the decisions they thought they were implementing were distorted.

Finally, in the real world of irreversible actions and high stakes, the need to maintain performance often overrides the need to learn by suppressing new strategies for fear they would cause present harm, even though they might yield great insight and prevent future harm.

Requirements for Successful Learning in Complex Systems

Thus we face grave impediments to learning in complex systems such as a nation, firm, or family. Every link in the feedback loops by which we might learn can be weakened or cut by a variety of structures. Some of these structures are physical or institutional features of the environment—the elements of dynamic complexity that reduce opportunities for controlled experimentation, prevent us from learning the consequences of our actions, and distort the outcome feedback we do receive. Some are consequences of our culture, group process, and inquiry skills. Still others are fundamental bounds on human cognition, particularly the poor quality of our mental maps and our inability to make correct inferences about the dynamics of complex nonlinear systems.

When Can Evolution Overcome the Impediments to Learning?

Given the many impediments to learning discussed above, how is it possible that people walked on the moon, or even get through the day without grave injury? Reflecting on this paradox, Toda (1962, p. 165) wrote:

> Man and rat are both incredibly stupid in an experimental room. On the other hand, psychology has paid little attention to the things they do in their normal habitats; man drives a car, plays complicated games, and organizes society, and rat is troublesomely cunning in the kitchen.

Many scholars resolve the paradox by arguing that evolution can lead to high performance without the improvement of our causal maps or accurate mental simulation. Consider learning to ride a bicycle. Few people can write, let alone solve, the equations of motion for the bicycle, yet many master bicycling by the age of six. Such examples—others include billiards (Friedman, 1953)—are often cited by economists who believe that human systems rapidly approach optimality through evolution (Lucas, 1987). In this view, learning does not require good mental models of the environment. All we require is the ability to generate new candidate decision rules sufficiently different from current procedures, and the ability to recognize and reward those that improve performance. Over time, selection of the best performing rules will lead to high performance without the need to understand how or why something works.

Evolution does occur, in both the biological and social worlds. Recent work with genetic algorithms and other simulated evolutionary processes (Nelson and Winter, 1982: Anderson, Arrow, and Pines, 1988) show that these "blind" processes often lead to rapid improvements in system performance. However, evolution leads to improvement only to the extent that: (1) the processes for generating new candidate rules provide for sufficient variety; (2) the better performing rules are rewarded by more frequent use; and (3) evolution proceeds rapidly compared to changes in the system itself.[12] However, dynamic complexity and the misperceptions of feedback discussed above reduce the effectiveness of all three.

Contrast learning to ride a bicycle with learning to invest successfully in real estate. The real estate industry suffers from chronic boom-and-bust cycles. Low vacancy rates lead to high rents and rising prices, leading developers to initiate many new projects. Development

continues until prices fall as the stock of buildings increases enough to bring up the vacancy rate. However, for several years after new development ceases, projects under construction continue to add to the stock of buildings. The stock of buildings overshoots, prices fall, and new construction remains low until vacancies drop, initiating the next cycle (Bakken, 1993; Hernandez, 1990; and Thornton, 1992, describe field studies of successful and unsuccessful developers that document the account here). The equations of motion for the real estate cycle are much simpler than those governing the bicycle. A simple, low-dimensional system dynamics model replicates the real estate cycle well (Jarmain, 1963; Bakken, 1993). Yet the boom-and-bust cycles in real estate persist over centuries (Hoyt, 1933), while novice riders quickly learn to pilot their bicycles smoothly. The differences must be sought in the effects of dynamic complexity on the efficacy of the feedbacks governing learning and evolution.

Consider first the bicycle. The conditions for learning are excellent: outcome feedback is available continuously with very short time delays between action and result. Feedback is salient and accurate. There are few confounding variables (what others in the neighborhood are doing is irrelevant). One can cycle around the driveway —and the learning loop—dozens of times in an afternoon. Thus one can try many different ways to ride (variety is easily generated), and can easily determine which work best (thus effectively selecting those that improve performance). In the next round of trials, one generates new experience in the neighborhood of what worked best before, and selects from these the best performing ways to ride. Furthermore the laws of physics and equations of motion for the bicycle do not change in response to the rider's decisions, so what is learned does not become obsolete. Thus evolution can work well.[13]

Consider now the problem of successful investing in the real estate industry. Time lags are substantial—it takes two to five years between the decision to develop a property and the completion of the project, still more time to cash out, and the buildings last at least 50 years. Even experienced developers work through only a few cycles in their careers, and so much changes over those decades it is difficult to draw general conclusions about the symptoms, much less the causes, of the dynamics. Information about rents, prices, construction costs, vacancies, migration patterns, and other relevant variables is extremely limited, incomplete, noisy, and ambiguous. Current prices and stories of successful deals are highly salient and concrete but also misleading, while the critically important supply pipeline and plans of other developers are abstract and unpersuasive. It is extremely difficult to relate current prices and costs to likely future costs and returns. It is not possible to conduct controlled experiments. As developers begin new projects, their actions alter a host of variables, including the availability and cost of construction crews, migration patterns, and business location decisions, all of which feed back to alter vacancies and prices and thus future development decisions. Unlike the bicycle, in real estate, what others in the neighborhood are doing matters a great deal: success in the market rapidly attracts new entrants, who then contribute to overbuilding and lower prices.

Evolution functions poorly in the real estate market both because there is much less variation in behavior and because selection is less effective. The slow dynamics mean there are fewer decisions than there are for the bicycle. Variation and experimentation are reduced due to the strong herd instinct in the industry. Groupthink and strong networks of communication among developers, bankers, and others lead to common knowledge and expectations. The costs of error are also asymmetric: it is better to be wrong with the crowd than wrong alone. Even if a developer wished to follow a contrarian strategy by buying properties when prices are depressed and pessimism reigns, few investors would be willing to lend the needed funds. Experimentation is also reduced because errors are punished much more severely (by bankruptcy and loss of reputation) than the skinned knees typical in bicycling. Without variation in developer strategy, meaningful performance differentials cannot arise, and selection will operate on noise. Finally, the feedbacks among market participants are so strong that evolution itself introduces variation in the environment that makes current knowledge obsolete (that is, the players, their strategies, and their environment are co-evolving).

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More important, evolution selects according to whatever fitness function is used to evaluate different strategies. Different fitness functions—values—reward

different behaviors. When short-run performance is rewarded, strategies yielding superior quarterly or annual results proliferate even though they may cause long-run ruin for all. The bias towards reward of short-run results is reinforced by the misperceptions of feedback, which make it hard to assign credit for long-term results to particular strategies or people. Most developers and bankers find the structure and dynamics of the industry so hard to understand that the effectiveness of strategies is evaluated well before the full consequences are observed. The short-time horizon for performance evaluation is reinforced by perverse incentives whereby deals that ultimately lose money generate fees up front. These incentives are themselves devices to reduce uncertainty about short-term cash flow. Thus, during booms, strategies based on maximum financial leverage and building "on spec" work best, while conservative investors lag far behind. Aggressive strategies proliferate as the apparent success of players like Donald Trump makes still more capital available to them and draws in a host of imitators. Selection thus rewards strategies that worsen the bust. Rather than leading to stability, evolution may select against conservative investors and increase the prevalence of speculators who destabilize the industry.

Improving the Learning Process

What, then, are the requirements for successful learning in complex systems? If we are to create useful protocols and tools for learning effectively in a world of dynamic complexity, we must attend to all of the impediments to learning. Figure 8 shows how the learning feedbacks would operate when all the impediments to learning are addressed. The diagram features a new feedback loop created by the use of "virtual worlds." Virtual worlds (the term is Schön's, 1983b) are formal models, or microworlds (Papert, 1980), in which the decision makers can refresh decision-making skills, conduct experiments, and play. They can be physical models, role plays, or computer simulations. In systems with significant dynamic complexity, computer simulation will typically be needed (though there are notable exceptions, such as the Beer Distribution Game and the Du Pont Maintenance Game (Carroll and Sterman, 1998), along with role-play/computer hybrids such as Fish Banks, Ltd. (Meadows, Fiddaman, and Shannon, 1993).

The costs of error are also asymmetric: it is better to be wrong with the crowd than wrong alone.

Virtual worlds have several virtues. They provide low-cost laboratories for learning. The virtual world allows time and space to be compressed or dilated. Actions can be repeated under the same or different conditions. One can stop the action to reflect. Decisions that are dangerous, infeasible, or unethical in the real system can be taken in the virtual world. Thus controlled experimentation becomes possible, and the time delays in the learning loop through the real world are dramatically reduced. In the real world, the irreversibility of many actions and the need to maintain high performance often override the goal of learning by preventing experiments with untried possibilities ("If it ain't broke, don't fix it"). In the virtual world, one can try strategies that one suspects will lead to poor performance or even (simulated) catastrophe. Often, pushing a system into extreme conditions reveals more about its structure and dynamics than incremental adjustments to successful strategies. Virtual worlds are the only practical way to experience catastrophe in advance of the real thing. Thus a great deal of the time that pilots spend in flight simulators is devoted to extreme conditions such as engine failure or explosive decompression.

Virtual worlds provide high-quality outcome feedback. In the People Express Management Flight Simulator (Sterman, 1988) and similar system dynamics simulations, for example, players receive perfect, immediate, undistorted, and complete outcome feedback. In a single afternoon, one can gain years of simulated "experience." The degree of random variation in the virtual world can be controlled. Virtual worlds offer the learner greater control over strategy, leading to more consistent decision making, and avoiding implementation failure and game playing. In contrast to the real world, which, like a black box, has a poorly resolved structure, virtual worlds can be "open boxes" whose assumptions are fully known and can even be modified by the learner.

Virtual worlds for learning and training are commonplace in the military, in pilot training, in power plant operations, and in many other real-time tasks where human

operators interact with complex technical systems. Virtual worlds are also common in professions such as architecture (Schön, 1983b). The use of virtual worlds in managerial tasks, where the simulation compresses into a day or an hour dynamics that extend over years or decades, is more recent and less widely adopted. Yet these are precisely the settings where dynamic complexity is most problematic, and the learning feedbacks described above least effective. Many virtual worlds for the study of dynamically complex settings have now been developed, and while further evaluative research is needed, they have enjoyed great success in pre-college education, universities, and corporations (see Gould, 1993; Graham, Morecroft, Senge, and Sterman, 1992; Morecroft and Sterman, 1994; and Mandinach and Cline, 1994).

Pitfalls of Virtual Worlds

Virtual worlds are effective when they engage people in what Dewey called "reflective thought," and in what Schön (1992) calls "reflective conversation with the situation." While the use of a virtual world may be necessary for effective learning in dynamically complex systems, virtual worlds do not guarantee that we will overcome the flaws in our mental models, scientific reasoning skills, and group process.

Obviously, while the virtual world enables controlled experimentation, it does not require the learner to apply the principles of scientific method. Many participants in model-based workshops lack training in scientific method and awareness of the pitfalls in the design and interpretation of experiments. A commonly observed behavior in workshops using management flight simulators is "trial and trial again," where players make incremental adjustments to their last strategy, then try again. Participants do not take time to reflect

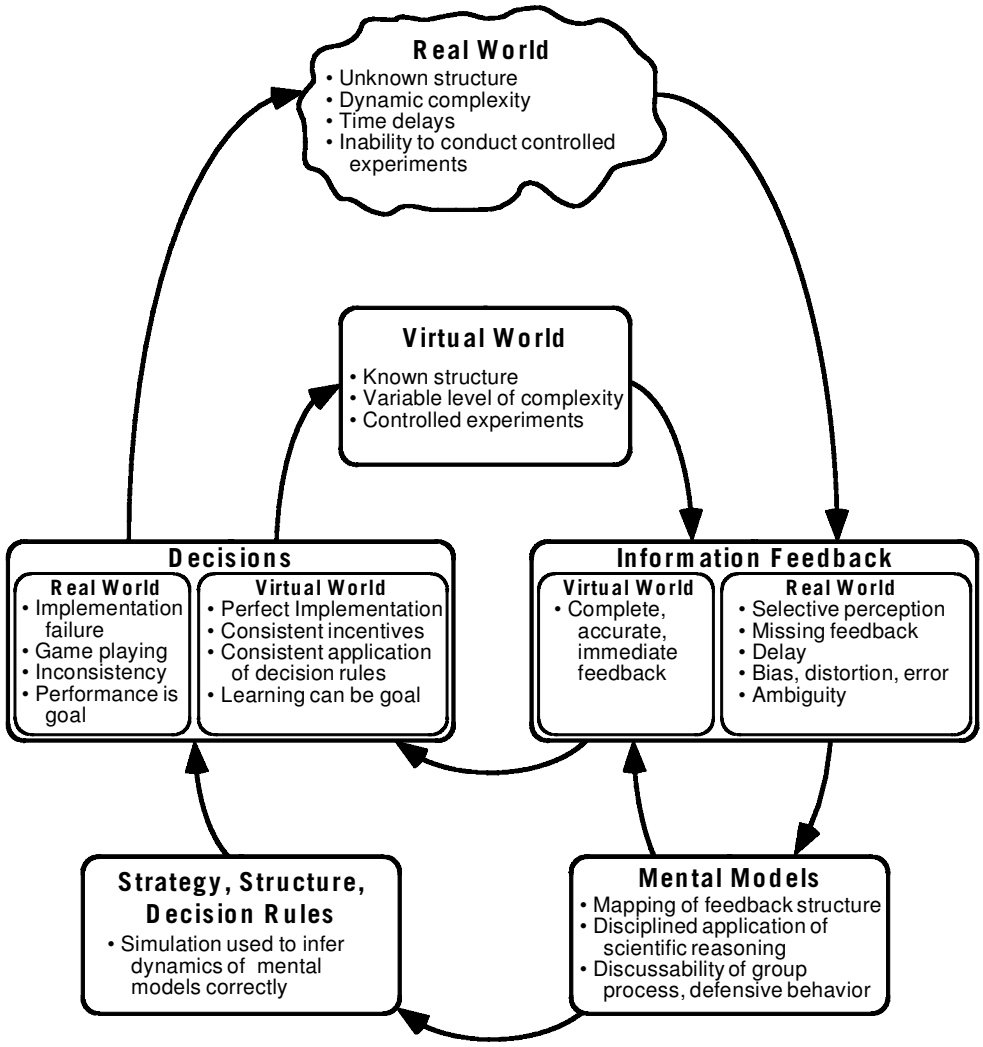


Figure 8. Idealized learning loops. Effective learning involves continuous experimentation in both the virtual world and real world, with feedback from both informing development of the mental models, the formal models, and the design of experiments for the next iteration.

on the outcome, identify discrepancies between the outcomes and their expectations, formulate hypotheses to explain the discrepancies, and then devise experiments to discriminate among the competing alternatives (Mass, 1991, gives guidelines for effective experimentation in simulation models). Effective learning in virtual worlds often requires training for participants in scientific method. Protocols for the use of simulations should be structured to encourage proper procedure, such as keeping laboratory notebooks, explicitly formulating hypotheses and presenting them to the group, and so on.

Defensive routines and groupthink can operate in the learning laboratory just as in the real organization. Indeed, protocols for effective learning in virtual worlds—such as public testing of hypotheses, accountability, and comparison of different strategies—can be highly threatening, inducing defensive reactions that prevent learning (Isaacs and Senge, 1992). The use of virtual worlds to stimulate learning in organizations often requires that the group spend time addressing its own defensive behavior. Managers unaccustomed to disciplined scientific reasoning and an open, trusting, environment with learning as its goal will have to build these basic skills before a virtual world can prove useful. Developing these skills takes effort and practice.

Still, settings with high dynamic complexity can garble the reflective conversation between the learner and the situation. Long time delays, causes and effects that are distant in time and space, and the confounding effects of multiple, nonlinear feedbacks can slow learning even for people with good insight and group process skills. Learning in virtual worlds can be accelerated when the protocols for simulator use help people learn how to represent complex feedback structures and understand their implications. To learn when dynamic complexity is high, participants must have confidence in the external validity of the virtual world. They must believe it mimics the relevant parts of the real world well enough that the lessons emerging from the virtual world apply to the real one. To develop such confidence, the virtual world must be an open box with assumptions that are accessible and modifiable. To learn from the open box, participants must become modelers, not merely players in a simulation.

In practice, effective learning from models occurs best—perhaps only—when the decision makers participate actively in the development of the model.

In practice, effective learning from models occurs best—perhaps only—when the decision makers participate actively in the development of the model. Modeling here includes the elicitation of the participants' existing mental models, including articulating the issues (problem structuring), selecting the model boundary and time horizon, and mapping the causal structure of the relevant system. Researchers in the soft operations research tradition have pioneered many methods to facilitate the elicitation and mapping process. Along with techniques developed in system dynamics, many tools and protocols for group model-building are now available, including causal loop diagrams, policy structure diagrams, interactive computer mapping, and various problem structuring and soft systems methods (see, e.g., Checkland, 1981; Eden, Jones, and Sims, 1983; Lane, 1993; Morecroft, 1982; Morecroft and Sterman, 1994; Reagan, et al., 1991; Richmond, 1987, 1993; Rosenhead, 1989; Senge and Sterman, 1992; and Wolstenholme, 1990).

Why Simulation Is Essential

Eliciting and mapping the participants' mental models, while necessary, is far from sufficient. As discussed above, the temporal and spatial boundaries of our mental models tend to be too narrow. They are dynamically deficient, omitting feedbacks, time delays, accumulations, and nonlinearities. The great virtue of many protocols and tools for elicitation is their ability to improve our models by encouraging people to identify the elements of dynamic complexity normally absent from mental models. However, most problem-structuring methods yield qualitative models that show causal relationships, but omit the parameters, functional forms, exogenous variables, and initial conditions needed to fully specify and test the model. Regardless of the form of the model or technique used, the result of the elicitation and mapping process is never more than a set of causal attributions—initial hypotheses about the structure of a system, which must then be tested.

The only practical way to test these models is simulation. The complexity of the cognitive maps produced in an elicitation workshop vastly exceeds our capacity to understand their implications. Qualitative maps are too ambiguous and too difficult to simulate mentally to provide much useful information on the adequacy of the model structure, or guidance about the future development of the system or the effects of policies.

Without simulation, even the best maps can only be tested and improved by relying on the learning feedback through the real world. As we have seen, this feedback is slow and often rendered ineffective by dynamic complexity, time delays, inadequate and ambiguous feedback, poor reasoning skills, defensive reactions, and the costs of experimentation. In these circumstances, simulation becomes the only reliable way to test the hypotheses emerging from elicitation techniques and other problem-structuring methods.

Some scholars argue that it is not possible to create valid formal models of human systems; that formal modeling can at best provide quantitative precision within preexisting problem definitions, but cannot lead to fundamentally new conceptions (for various views see Dreyfus and Dreyfus, 1986, and the discussion in Lane, 1993). On the contrary, formalizing qualitative models and testing them via simulation often leads to radical changes in the way we construe reality and carve problems out of "messes" (Ackoff, 1979). Simulation speeds and strengthens the learning feedbacks. Discrepancies between the formal and mental model stimulate improvements in both, including changes in basic assumptions such as model boundary, time horizon, and dynamic hypotheses (see Forrester, 1985, and Homer, 1992, for philosophy and an example). Without the discipline and constraint imposed by the rigorous testing that simulation enables, it becomes all too easy for mental models to be driven by unconscious bias or deliberate ideology.

Some argue that formalization forces the modeler to omit important aspects of the problem to preserve tractability and enable theorems to be proved, or to omit soft variables for which no numerical data exist. These are indeed dangers. The literature of the social sciences is replete with models in which elegant theorems are derived from questionable axioms, where simplicity dominates utility, and where variables known to be important are ignored because data to estimate parameters are unavailable. System dynamics was designed specifically to overcome these limitations. From the beginning, it stressed the development of useful, realistic models, models unconstrained by the demands of analytic tractability, based on realistic assumptions about human behavior, grounded in field study of decision making, and utilizing the full range of available data—not only numerical data—to specify and estimate relationships (see Forrester, 1987).

As to the notion that "useful" and "valid" formal models of human behavior cannot be developed, space does not permit full rebuttal of this position here. However, as Kenneth Boulding points out, "anything that exists is possible," and many formal models of human behavior in systems with "soft" variables exist (see, e.g., the models in Levine and Fitzgerald, 1992; Roberts, 1978; Langley, et al., 1987; Sterman, 1985; Homer, 1985; and many of the models cited in Sastry and Sterman, 1993).

Is it possible to learn effectively in complex settings without simulation? Can the use of problem-structuring methods, elicitation techniques, and other qualitative systems methods overcome the impediments to learning? If intuition is developed highly enough, if systems thinking is incorporated in pre-college education early enough, or if we are taught how to recognize a set of "system archetypes" (Senge, 1990), will we be able to improve our intuition about complex dynamics enough to render simulation unnecessary?

When experimentation in the real system is infeasible, simulation becomes the main, and perhaps the only, way learners can discover for themselves how complex systems work.

The answer is clearly, No. Systems thinking techniques, including system dynamics and qualitative methods such as soft systems analysis, can enhance our intuition about complex situations, just as studying physics can improve our intuition about the natural world.[14] As Wolstenholme (1990) argues, qualitative systems tools should be made widely available so that those with limited mathematical background can benefit from them. I am a strong advocate for the introduction of system dynamics and related methods at all levels of the educational system. Yet even if children began serious study of physics in kindergarten, and contin-

ued it through PhDs, it is ludicrous to suggest that they could, by intuition alone, predict the track of a hurricane or understand what happens when two galaxies collide. Many human systems are just as complex. Even if children learn to think in systems terms—a goal I believe is vitally important—it will still be necessary to develop formal models, solved by simulation, to learn about such systems.

Most important, when experimentation in the real system is infeasible, simulation becomes the main, and perhaps the only, way learners can discover *for themselves* how complex systems work. The alternative is rote learning based on the authority of the teacher and textbook, a pedagogy that dulls creativity and stunts the development of the scientific reasoning skills needed to learn about complexity.

Conclusion

Complex dynamic systems present multiple barriers to learning. The challenge of bettering the way we learn about these systems is itself a classic systems problem. Overcoming the barriers to learning requires a synthesis of many methods and disciplines, from mathematics and computer science to psychology and organizational theory. Theoretical studies must be integrated with field work. Interventions in real organizations must be subjected to rigorous follow-up research.

There are many reasons for hope. Recent advances in interactive modeling, tools for representation of feedback structure, and simulation software make it possible for anyone to engage in the modeling process. Corporations, universities, and schools are experimenting vigorously. Much further work is needed to test the utility of the tools and protocols, evaluate their impact on individual and organizational learning, and develop effective ways to train others to use them. The more rigorously we apply the principles discussed here to our own theories and our own practices, the faster we will learn how to learn in and about complex systems.

Notes

1. By "scientific," I mean an endeavor much like the "normal science" of Thomas Kuhn (1970), that is, the disciplined activity of a community that builds a cumulative stock of knowledge according to certain principles, including documentation and publication of methods and results, replicability, and transferability (the knowledge can be learned and used by others).
2. Depending on the time delays and other elements of dynamic complexity in the system, these examples may not converge. It takes only a little ice, fog, fatigue, or alcohol to cause an accident, and equilibrium eludes many industries that experience chronic business cycles.
3. See *Science*, 256 (12 June 1992), 1520–1521.
4. Even more obviously, our ability to see a three-dimensional world is the result of extensive modeling by the visual processing system, since the retina images a planar projection of the visual field.
5. Technically, negative loops with no time delays are first order; the eigenvalue of the linearized system can only be real and oscillation is impossible. Adding delays (state variables) allows the eigenvalues to become complex conjugates, yielding oscillatory solutions. Whether the oscillations of the linearized system are damped or expanding depends on the parameters. All else equal, the more phase lag in a control loop, the less stable the system will be.
6. Philosophers have long noted the critical role of beliefs in conditioning perception. Sterman (1985) provides a brief summary.
7. These data are summarized in Culotta and Koshland, 1993.
8. The example is not merely an example of hindsight bias. Given the weak theoretical basis for, and null results of, the sterilizing immunity approach, it does not seem reasonable to design vaccination trials so that the experiments could generate data only on the one hypothesis of sterilizing immunity. Far from illustrating hindsight bias, the example illustrates the overconfidence bias (too much faith that sterilizing immunity would work) and the failure to generate sufficient alternative hypotheses. It is too soon to know which approach will work, if either, and the example does not imply that work on sterilizing immunity should stop. But the favored hypothesis led to experimental protocols that precluded the observation of data that might have led to other possibilities, thus slowing learning.
9. Despite its difficulties, I am not arguing that econometrics should be abandoned. On the contrary, wise use of statistical estimation is important to good system dynamics practice, and more effort should be devoted to the use of these tools in simulation model development and testing.

10. This and other management flight simulators are available from the author.
11. The summary of the Wason test is drawn from Plous, 1993, chapter 20.
12. Of course, in systems such as ecosystems or markets in evolution is itself a source of change. Such systems involve populations of entities all mutually co-evolving, so that the evolutionary landscape shifts because of the evolutionary process itself.
13. Perhaps most important, bicycling is a motor skill drawing on neural and sensory systems that evolved to provide accurate feedback about—and control of—balance, position, and motion. Balancing and pedaling require little conscious effort. The decision to invest in real estate, in contrast, is largely conscious and cognitive (though emotions often loom large as well). High survival value over millions of years caused excellent motor skills to evolve, while the cognitive skills required to understand the assumptions behind a spreadsheet or the dynamic complexity of a market have led to reproductive advantage only recently, if at all.
14. Such education is desperately needed. When asked the question, "If a pen is dropped on the moon, will it: (a) float away, (b) float where it is, or (c) fall to the surface of the moon?" forty-eight of 168 students in physics courses at Iowa State University gave incorrect answers. A typical student explanation was, "The gravity of the moon can be said to be negligible, and also the moon's a vacuum. There is no external force on the pen, therefore it will float where it is." (Partee, personal communication, 1993).

References

Ackoff, R. "The Future of Operational Research is Past." *Journal of the Operational Research Society* 30 (1979): 93–104.

Adams, H. *The Education of Henry Adams* (Boston: Houghton-Mifflin, 1918).

Anderson, P., K. Arrow, and D. Pines, eds. *The Economy as an Evolving Complex System* (Redwood City, CA: Addison-Wesley, 1988).

Argyris, C. *Strategy, Change, and Defensive Routines* (Boston: Pitman, 1985).

Argyris, C., R. Putnam, and D. Smith. *Action Science* (San Francisco: Jossey-Bass, 1985).

Argyris, C. and D. Schön. *Organizational Learning: A Theory of Action Approach* (Reading, MA: Addison-Wesley, 1978).

Axelrod, R. *The Structure of Decision: The Cognitive Maps of Political Elites* (Princeton: Princeton University Press, 1976).

Bakken, B. "Learning and Transfer of Understanding in Dynamic Decision Environments." Unpublished PhD Dissertation, MIT Sloan School of Management, Cambridge, MA 02142, 1993.

Bower, G. and D. Morrow. "Mental Models in Narrative Comprehension." *Science*, 247 (5 January 1990): 44–48.

Brehmer, B. "In One Word: Not from Experience." *Acta Psychologica* 45 (1980): 223–241.

Brehmer, B. "Feedback Delays and Control in Complex Dynamic Systems," in *Computer Based Management of Complex Systems*," eds. P. Milling and E. Zahn. (Berlin: Springer Verlag, 1989): 189–196.

Brehmer, B. "Dynamic Decision Making: Human Control of Complex Systems." *Acta Psychologica* 81 (1992): 211–241.

Bruner, J. S. and L. J. Postman. "On the Perception of Incongruity: A Paradigm." *Journal of Personality* 18 (1949): 206–223.

Carroll, J. S. and J. D. Sterman. "Playing the Maintenance Game: How Mental Models Drive Organizational Decisions," in *Debating Rationality*: *Nonrational Elements of Organizational Decision Making*, eds. J. J. Halpern and R. N. Stern (Ithaca, NY: Cornell University Press, 1998): 91–121.

Checkland, P. *Systems Thinking, Systems Practice* (Chichester: John Wiley & Sons, 1981).

Cheng, P. and R. Nisbett. "Pragmatic Reasoning Schemas" *Cognitive Psychology*, 17 (1985): 391–416.

Cobb, J. and H. Daly. *For the Common Good* (Boston: Beacon Press, 1989).

Cohen, J.. "A New Goal: Preventing Disease, Not Infection." *Science*, 262 (17 December 1993): 1820–1821.

Culotta, E. and D. Koshland. "Molecule of the Year." *Science*, 262 (24 December 1993): 1960.

Davis, H. and R. Hogarth. "Rethinking Management Education: A View from Chicago." Selected paper 72, University of Chicago, Graduate School of Business, 1992.

Diehl, E. and J. D. Sterman. "Effects of Feedback Complexity on Dynamic Decision Making." *Organizational Behavior and Human Decision Processes* 62, 2 (1995): 198–215.

Dörner, D. "On the Difficulties People Have in Dealing with Complexity." *Simulation and Games* 11, 1 (1980): 87–106.

Dreyfus, H. L. and S. E. Dreyfus. *Mind over Machine* (New York: Free Press, 1986).

Eden, C., S. Jones, and D. Sims. *Messing About in Problems* (Oxford: Pergamon Press, 1983).

Einhorn, H. and R. Hogarth. "Confidence in Judgment: Persistence of the Illusion of Validity." *Psychological Review* 85 (1978): 395–476.

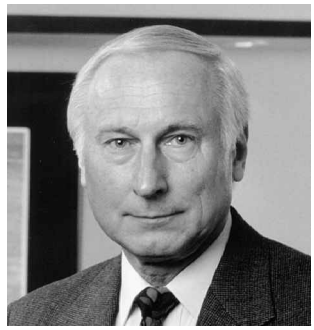
Einhorn, H. and R. Hogarth. "Judging Probable Cause." *Psychological Bulletin*, 99 (1986): 3–19.

Farman, J., B. Gardiner, and J. Shanklin. "Large Losses of Total Ozone in Antarctica Reveal Seasonal ClO/NO_2 Interaction." *Nature* 315 (1985): 207.
Forrester, J. W. *Industrial Dynamics* (Cambridge: MIT Press, 1961).
Forrester, J. W. *Urban Dynamics* (Cambridge: MIT Press, 1969).
Forrester, J. W. "Counterintuitive Behavior of Social Systems." *Technology Review* 73, 3 (January 1971): 52–68.
Forrester, J. W. "'The' Model versus a Modeling 'Process'." *System Dynamics Review* 1, 1 (1985): 133–134.
Forrester, J. W. "14 'Obvious Truths'." *System Dynamics Review* 3, 2 (1987): 156–159.
Forrester, J. W. "Policies, Decisions, and Information Sources for Modeling." *European Journal of Operational Research* 59, 1 (1992): 42–63.
Friedman, M. "The Methodology of Positive Economics," in *Essays in Positive Economics*, ed. M. Friedman (Chicago: University of Chicago Press, 1953).
Funke, J. "Solving Complex Problems: Exploration and Control of Complex Systems," in *Complex Problem Solving: Principles and Mechanisms,* eds. R. Sternberg and P. Frensch (Hillsdale, NJ: Lawrence Erlbaum Associates, 1991).
Gentner, D. and A. Stevens. *Mental Models* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983).
Graham, A. K., J. D. Morecroft, P. M. Senge, and J. D. Sterman. "Model Supported Case Studies for Management Education." *European Journal of Operational Research* 59, 1 (1992): 151–166.
Gould, J. "Systems Thinking in Education." Special issue of the *System Dynamics Review,* 9, 2 (1993).
Halford, G. *Children's Understanding: The Development of Mental Models* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1993).
Hall, R. I. "A System Pathology of an Organization: The Rise and Fall of the Old *Saturday Evening Post*." *Administrative Science Quarterly* 21, 2 (1976): 185–211.
Hernandez, K. "Learning in Real Estate: The Role of the Development System in Creating Oversupply." Unpublished Master's Thesis, MIT Sloan School of Management, Cambridge, MA 02142, 1990.
Hogarth, R. "Beyond Discrete Biases: Functional and Dysfunctional Aspects of Judgmental Heuristics." *Psychological Bulletin* 90 (1981): 197–217.
Hogarth, R. *Judgement and Choice, 2nd Edition* (Chichester, England: John Wiley & Sons, 1987).
Homer, J. "A System Dynamics Model of National Cocaine Prevalence." *System Dynamics Review* 9, 1 (1992): 49–78.
Homer, J. B. "Worker Burnout: A Dynamic Model with Implications for Prevention and Control." *System Dynamics Review* 1, 1 (1985): 42–62.
Hoyt, H. *One Hundred Years of Land Values in Chicago* (Chicago: University of Chicago Press, 1993).
Isaacs, W. and P. Senge. "Overcoming Limits to Learning in Computer-Based Learning Environments." *European Journal of Operational Research* 59, 1 (1992): 183–196.
Janis, I. L. *Groupthink: Psychological Studies of Policy Decisions and Fiascoes,* 2nd ed. (Boston: Houghton Mifflin, 1982).
Jarmain, W. E. *Problems in Industrial Dynamics* (Cambridge, MA: MIT Press, 1963).
Johnson-Laird, P. *Mental Models: Toward a Cognitive Science of Language, Inference, and Consciousness* (Cambridge, England: Cambridge University Press, 1983).
Kahneman, D., P. Slovic, and A. Tversky. *Judgment under Uncertainty: Heuristics and Biases* (Cambridge: Cambridge University Press, 1982).
Kampmann, C. and J. D. Sterman. "Feedback Complexity, Bounded Rationality, and Market Dynamics." Working paper, System Dynamics Group, MIT Sloan School of Management, Cambridge, MA 02142, 1994. Available at < web.mit.edu/jsterman/www > .
Klayman, J. and Y. Ha. "Confirmation, Disconfirmation, and Information in Hypothesis Testing." *Psychological Review* 94 (1987): 211–28.
Kleinmuntz, D., and J. Thomas. "The Value of Action and Inference in Dynamic Decision Making." *Organizational Behavior and Human Decision Processes* 39, 3(1987): 341–364.
Kuhn, T. *The Structure of Scientific Revolutions,* 2nd ed. (Chicago: University of Chicago Press, 1970).
Lane, D. "With a Little Help from Our Friends: How Third-Generation System Dynamics and the Problem Structuring Techniques of 'Soft' OR Can Learn from Each Other," in *Proceedings of the 1993 International System Dynamics Conference*, eds. E. Zepeda and J. Machuca (Cancún, Mexico: Monterrey Institute of Technology, 1993): 235–244.
Langley, P., H. A. Simon, G. L. Bradshaw, and J. M. Zytkow. *Scientific Discovery: Computational Explorations of the Creative Processes* (Cambridge: MIT Press, 1987).
Leamer, E. "Let's Take the Con Out of Econometrics." *American Economic Review* 73, 1 (1983): 31–43.
Levine, R. and H. Fitzgerald. *Analysis of Dynamic Psychological Systems,* 2 Vols. (New York: Plenum Press, 1992).
Lucas, R. "Adaptive Behavior and Economic Theory," in *Rational Choice: The Contrast Between Economics and Psychology,* eds. R. Hogarth. and M. Reder (Chicago: University of Chicago Press, 1987).

Machiavelli, N. "Discourses," in *The Portable Machiavelli,* eds. and trans. P. Bondanella and M. Musa (New York: Viking Press, 1979).
Mandinach, E. and H. Cline. *Classroom Dynamics: Implementing a Technology-Based Learning Environment* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1994).
Mann, C. "Radiation: Balancing the Record." *Science* 263 (28 January 1994): 470–473.
Mass, N. "Diagnosing Surprise Model Behavior: A Tool for Evolving Behavioral and Policy Insights." *System Dynamics Review* 7, 1 (1991): 68–86.
Meadows, D. H. "Whole Earth Models and Systems." *CoEvolution Quarterly* (Summer 1982): 98–108.
Meadows, D. H., D. L. Meadows, and J. Randers. *Beyond the Limits* (Post Mills, VT: Chelsea Green Publishing Company, 1992).
Meadows, D. H., J. Richardson, and G. Bruckmann. *Groping in the Dark* (London, England: John Wiley & Sons, 1982).
Meadows, D. L., T. Fiddaman, and D. Shannon. *Fish Banks, Ltd.: A Micro-computer Assisted Group Simulation that Teaches Principles of Sustainable Management of Renewable Natural Resources,* 3rd edition, Laboratory for Interactive Learning, Hood House, University of New Hampshire, Durham, NH 03824, 1993.
Molina, M. and F. S. Rowland. "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atomic Catalysed Destruction of Ozone." *Nature* 249 (1974): 810.
Morecroft, J. "A Critical Review of Diagramming Tools for Conceptualizing Feedback Models." *Dynamica* 8, 1 (1982): 20–29.
Morecroft, J. and J. D. Sterman, J.D., eds. *Modeling for Learning* (Portland, OR: Productivity Press, 1994).
Nelson, R. and S. Winter. *An Evolutionary Theory of Economic Change* (Cambridge, MA: Harvard University Press, 1982).
Paich, M. and J. D. Sterman. "Boom, Bust, and Failures to Learn in Experimental Markets." *Management Science* 39, 12 (1993): 1439–1458.
Partee, J. "Heavy Boots." E-mail from partee@iastate.edu. 1993.
Papert, S. *Mindstorms* (New York: Basic Books, 1980).
Plous, S. *The Psychology of Judgment and Decision Making* (New York: McGraw Hill, 1993).
Powers, W. "Feedback: Beyond Behaviorism." *Science* 179 (1973): 351–356.
Reagan-Cirincione, P., S. Schuman, G. Richardson, and S. Dorf. "Decision Modeling: Tools for Strategic Thinking." *Interfaces* 21, 6 (1991): 52–65.
Richardson, G. *Feedback Thought in Social Science and Systems Theory* (Philadelphia: University of Pennsylvania Press, 1991).
Richmond, B. *The Strategic Forum: From Vision to Operating Policies and Back Again*, High Performance Systems, 13 Dartmouth College Highway, Lyme, NH 03768, 1987. Richmond, B. "Systems Thinking: Critical Thinking Skills for the 1990s and Beyond," *System Dynamics Review* 9, 2 (1993): 113-134.
Roberts, E. B., ed. *Managerial Applications of System Dynamics* (Portland, OR: Productivity Press, 1978).
Robinson, J. "A Day for the Capitol to Consider its Stars." *Boston Globe* (4 May 1988): 1.
Rosenhead, J. ed. *Rational Analysis for a Problematic World: Problem Structuring Methods for Complexity, Uncertainty, and Conflict* (Chichester, England: John Wiley & Sons. 1989).
Ross, L. "The Intuitive Psychologist and His Shortcomings: Distortions in the Attribution Process," in *Advances in Experimental Social Psychology*, vol. 10, ed. L. Berkowitz (New York: Academic Press, 1977).
Sastry, A., and J. D. Sterman. "Desert Island Dynamics: An Annotated Guide to the Essential System Dynamics Literature," in *Proceedings of the 1993 International System Dynamics Conference*, eds. E. Zepeda and J. Machuca (Cancún, Mexico: Monterrey Institute of Technology, 1993): 466–475. Available at < web.mit.edu/jsterman/www > .
Schank, R. and R. Abelson. *Scripts, Plans, Goals, and Understanding* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1977).
Schein, E. *Process Consultation: Its Role in Organization Development* (Reading, MA: Addison-Wesley, 1969).
Schein, E. *Organizational Culture and Leadership* (San Francisco: Jossey-Bass, 1985).
Schein, E. *Process Consultation*, Vol. II (Reading, MA: Addison-Wesley, 1987).
Schneiderman, A. "Setting Quality Goals." *Quality Progress* (April 1988): 55–57.
Schön, D. "Organizational Learning," in *Beyond Method*, ed. G. Morgan (London, England: Sage 1983a).
Schön, D. *The Reflective Practitioner* (New York: Basic Books, 1983b).
Schön, D. "The Theory of Inquiry: Dewey's Legacy to Education." *Curriculum Inquiry* 22, 2 (1992): 119–139.
Senge, P. *The Fifth Discipline: The Art and Practice of the Learning Organization* (New York: Doubleday, 1990).
Senge, P. and J. D. Sterman. "Systems Thinking and Organizational Learning: Acting Locally and

Thinking Globally in the Organization of the Future." *European Journal of Operational Research* 59, 1 (1992): 137–150.
Shaughnessy, D. "Bogged Down." *Boston Globe,* Section 3 (15 March 1987): 20.
Shewhart, W. *Statistical Method from the Viewpoint of Quality Control* (Washington, DC: US Department of Agriculture, 1939).
Shiba, S., A. Graham, and D. Walden. *A New American TQM: Four Practical Revolutions in Management* (Portland, OR: Productivity Press, 1993).
Simon, H. A. "Rational Decision-making in Business Organizations." *American Economic Review* 69 (1979): 493–513.
Simon, H. A. *Models of Bounded Rationality* (Cambridge: MIT Press, 1982).
Smith, V., G. Suchanek, and A. Williams. "Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Asset Markets." *Econometrica* 56, 5 (1988): 1119–1152.
Sterman, J. D. "The Growth of Knowledge: Testing a Theory of Scientific Revolutions with a Formal Model." *Technological Forecasting and Social Change* 28, 2 (1985): 93–122.
Sterman, J. D. *People Express Management Flight Simulator.* Software and Briefing Book. Available from author, MIT Sloan School of Management, MIT, Cambridge, MA 02142, 1988.
Sterman, J. D. "Misperceptions of Feedback in Dynamic Decision Making." *Organizational Behavior and Human Decision Processes* 43, 3 (1989a): 301–335.
Sterman, J. D. "Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment." *Management Science* 35, 3 (1989b): 321–339.
Sterman, J. D. "Deterministic Chaos in an Experimental Economic System." *Journal of Economic Behavior and Organization* 12 (1989c): 1–28.
Sterman, J. D. "Teaching Takes Off: Flight Simulators for Management Education." *OR/MS Today* (October 1992): 40–44.
Sterman, J. D., N. Repenning, and F. Kofman. "Unanticipated Side Effects of Successful Quality Programs: Exploring a Paradox of Organizational Improvement." *Management Science* 43, 4 (1997): 501–521.
Stolarski, R. and R. Cicerone. "Stratospheric Chlorine: A Possible Sink for Ozone." *Canadian Journal of Chemistry* 52 (1974): 1610.
Toda, M. "The Design of a Fungus-Eater: A Model of Human Behavior in an Unsophisticated Environment." *Behavioral Science* 7 (1962): 164–83.
Thornton, L. "Real Estate Development Firms as Learning Organizations: Systems Thinking as a Methodology for Strategic Planning." Unpublished Master's Thesis, MIT Center for Real Estate Development, Cambridge, MA 02142, 1992.
Vennix, J. *Mental Models and Computer Models.* PhD thesis. The Netherlands: Nijmegen Institute for Cognition Research and Information Technology, 1990.
Wagenaar, W. and S. Sagaria. "Misperception of Exponential Growth." *Perception and Psychophysics* 18 (1975): 416–422.
Wagenaar, W. and H. Timmers. "Extrapolation of Exponential Time Series Is Not Enhanced by Having More Data Points." *Perception and Psychophysics* 24 (1978): 182–184.
Wagenaar, W. and H. Timmers. "The Pond-and-Duckweed Problem: Three Experiments in the Misperception of Experimental Growth." *Acta Psychlogica* 43 (1979: 239–251).
Walton, M. *The Deming Management Method* (New York: Dodd, Mead & Co., 1986).
Wason, P. and P. Johnson-Laird. *Psychology of Reasoning: Structure and Content* (Cambridge, MA: Harvard University Press, 1972).
Wolstenholme, E. F. *System Enquiry: A System Dynamics Approach* (Chichester, England: John Wiley & Sons, 1990).

Commentary by Ray Stata



Ray Stata
Chairman, Analog Devices, Inc.

John Sterman's article, "Learning In and About Complex Systems," is an eclectic tour de force that captures much of what has been learned about how complex systems work and don't work, and approaches to improving their performance. While Sterman brings many valuable insights, the mood—if not the conclusions—of his paper is, in my view, overly pessimistic about the human capacity to significantly improve the performance of complex organizations that are undergoing rapid change. I agree that there is little hope to avoid dynamic excesses in macro markets like equity and real estate investments. But in business organizations where I have some familiarity, I am more optimistic than Sterman about our ability to learn and improve performance.

I am optimistic because there is already so much room to improve performance by means that in themselves are not so complex. For example, it's amazing how few organizations have truly em-

braced the first axiom of systems thinking; namely, to paraphrase Ackoff, "that the performance of a system depends much more on how well the parts work together than on how they work separately." Gradually, organizations are finding better ways to align individuals and groups, each with purposes of their own, with the common purpose of the organization of which they are a part. One way is to redesign organization structures to replace, or at least complement, vertical stovepipes with more formal horizontal cross-function or cross-organization pipelines. Another way is to redesign information systems to alter the way organization performance is measured, such as with Schneiderman's Balanced Scorecard, to provide more useful data and analysis, and to make progress toward shared goals more visible. In the famous Beer Game, the bizarre behavior of players operating in complete isolation will be radically altered by information systems that keep participants in the supply chain updated on the status of inventories in the system, and on changes in end-user demand. Likewise, in real world distribution systems, participants in supply chains are learning the value of shared information.

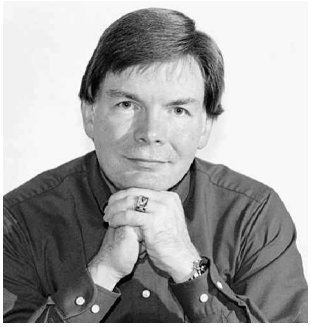
From another perspective, in my company we are experimenting with training that helps employees identify and allay defensive routines so as to better understand and respect each other's mental models, to reframe their positions based on valuing diversity and multi-views of the world, to enhance their conversation skills in order to improve the quality of relationships and the reliability of commitments to customers and coworkers, and to treat breakdowns as opportunities for improving the system instead of blaming people for problems. Even the simplistic methods employed in TQM, like the PDCA cycle, have had significant impact on the ability of many organizations to continuously learn and improve. So I assert that there are many not-so-complex approaches we can take to improve dramatically the capability of complex organizations to learn and improve.

There is also great value in more complex approaches, like system modeling and simulation, to reveal and stimulate learning opportunities that are not otherwise accessible directly through our human faculties. However, I see two problems with Sterman's assertion that, "in practice, effective learning from models occurs best and perhaps only when decision-makers participate actively in the development of the model." First, there are not yet enough skilled system dynamists available to facilitate the involvement of decision-makers on a scale that will have broad impact on industry performance. And second, even if there were enough skilled system dynamists, it's been my experience that by the time managers have risen to a level where they can have a real impact on the organization, they are too busy to devote the time and effort required for such an intensive learning experience. Look at how many senior executives today have not taken the time to learn how to engage in e-mail or to surf the web!

You have to catch professionals early in their careers, when they still have the time and interest to learn challenging new skills and technology. In this regard, through Sterman's initiative, MIT is at the forefront in introducing all of its MBA students to systems thinking, virtual worlds, and simulation methods. When this generation becomes senior executives, it will already be "systems literate," and system dynamics facilitators will be readily available. In the meantime, even busy executives will have the time and interest to learn how particular system archetypes apply to their businesses, and to review the results of simulations prepared by systems specialists.

It's not that Sterman is wrong. He's just ahead of the pack, as he should be. Along the way there are already many exciting opportunities to employ systems thinking to improve the performance of complex organizations.

Commentary by Richard Karash



Richard Karash
Independent Consultant, Boston

John Sterman's article is essential reading for anyone who engages in serious learning to be more effective in the world. It is a master catalogue of why it is so difficult for us to learn from day-to-day experience, even when we are paying attention.

As I read John's article, I thought of an anecdote about the difficulties of learning from experience that appears in Michael Polanyi's *Personal Knowledge* (University of Chicago Press, 1974). For hundreds of years, people have believed in astrology despite little evidence to support astrological concepts, and lack of a plausible causal mechanism. Polanyi contrasts the persistence of astrology with 18th and 19th century skepticism of hypnotism (now widely accepted in medicine and science as a useful tool). Hypnotism had been practiced for a while when Fritz Mesmer (1734–1815) made it a practical medical tool for eliminating pain in surgery. In that time, before the invention of anesthesia, a method for painless surgery would have been a great advance for humanity. But the

medical/scientific world wouldn't listen. "Scientific skepticism brushed aside all instances of hypnotic phenomena, which, even in the face of systematic demonstrations by Mesmer and his successors, denied the reality of hypnotic phenomena for another century," Polanyi writes.

Polanyi's anecdote raises two questions:

1. How do we know the scientific method is reliable in any specific instance? After all, people using rigorous scientific methods were wrong about hypnosis for a hundred years.
2. Do research results really affect public opinion and belief? Does the public learn from data that supports the effectiveness of a new approach?

My concern about our approach to learning is deeper than the two questions above. In most learning efforts, an objective is to increase our ability to get the results we want to get. As an objective, this is fine. But it is an entirely different matter to carry a mental model so that we can reliably produce the results we want to get. Or that others can. From there, it's just a small step to the mental model that other people should be able to produce the results we want . . . or else there's something wrong with those people. It's easy to find examples where people's actions appear to be consistent with such a belief.

Turning this model inward, we often see people apparently operating under the assumption that their actions affect others but not themselves. I wonder if the "results-with-certainty" mental model is lurking in our community, and what effects it might have. Professor Maturana's stimulating lectures at SoL's 1998 annual meeting, as well as his theories and experiments on the nervous system, point to a different mental model: each time we interact with another person, we might be able to stimulate a response, but—unless our action kills someone—the nature of that person's response depends on the state of his or her nervous system. In other words, we can't count on causing another human being to do any specific thing.

Further, each interaction with the rest of the world affects us in ways we cannot control (see figure 1). We evolve with the system. We have intentions, we have desires, and we seek to produce the results we want. Yet, no matter how well we manage the complexity of the system, we cannot reliably produce a predetermined result. And we cannot prevent the rest of the system from changing us because we are not the only ones influencing outcomes. The circularity of actions and responses feeding each other limit any one person's control. John Sterman believes that people generally operate with defective causal maps that seem limited to decision rules and outcomes. I propose another essential missing feature: mutual evolution and the impossibility of results with certainty.

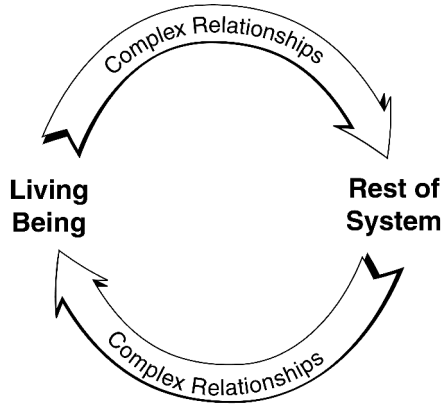


Figure 1. This diagram illustrates that we are constantly affecting the rest of the system while the rest of the system is affecting us. The arrows are not the simple arrows of causal loop diagrams. Instead, they represent a complex network of state variables and causal relationships.

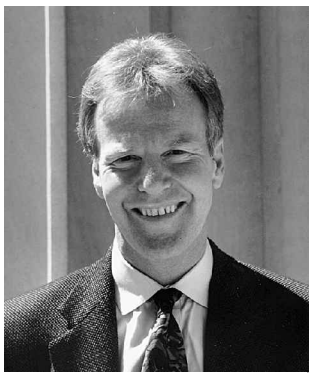
There's a general mental model that we already understand things well enough to make reasonably effective choices. What's apparent to me is that the ability to see systems—in other words, to break through John Sterman's barriers to learning—is different in different people. Some people pick up systems thinking more quickly than others do. I think that while everyone can increase his or her abilities, it's easier for some types of people and much harder for other types of people. Type theories, such as Seagal and Horne's Human Dynamics or Myers-Briggs, may account for learning differences.

As practitioners of systems thinking, I think we expend too much effort trying to spread the word universally. I would rather see us develop our capacity for having effective relationships with people whose thinking patterns are very different from ours. Trying to impose our thinking on others, especially if we think less of them for struggling with it, is counterproductive. By being more genuine in our acceptance of other types, I suspect we could learn a great deal. And by being more open to other thinking patterns, we may find value in ideas that initially seemed off the mark. After all, don't we wish others would be open-minded with respect to the credibility of our own field? And isn't it this capacity, developed both personally and collectively, that could keep us from overlooking the next Fritz Mesmer who appears with an effective remedy we don't yet understand? I don't believe it when my astrologer friend speaks. But I am paying attention.

FEATURE

Systems Change in Education

Peter M. Senge



Peter M. Senge
Senior lecturer, Massachusetts Institute of Technology
Chairperson,
the Council of Trustees
of the Society for Organizational Learning

Based on Talk at the 30th Anniversary Symposium of the Comer School Development Program, Yale University, April 30, 1998

Unlike most of you here today, I do not spend my life in schools. I do spend a great deal of time working with businesses, and I have grown to have great interest in the health of enterprises in general. In particular, I am involved in a consortium of organizations, now called SoL (formerly the MIT Organizational Learning Center), that has been fostering collaboration for fundamental change for almost ten years. This consortium probably has some similarities to the Comer Project, in the sense that it arose out of a belief that no institution working by itself could ever overcome the extraordinary range of hurdles that are necessary to bring about significant change. To sustain systemic change requires working together.

Business is probably the most influential institution in society today. If you want to bring about fundamental change, business is a good place to begin. It is a good place to demonstrate what is possible. I have worked in a variety of settings in public education, and in my opinion, it's harder to bring about the kind of changes that are needed in the institutions of public education than it is in business. And it's not easy in business.

Yet, ultimately, changes of the sort we have been working for in business will probably not be sustainable without parallel changes in public education. In truth, it makes little sense, for example, to develop systems thinking starting with middle aged adults who have spent almost their entire lives in institutions based on reductionism. For a long time, I have had the notion that, perhaps, we could build momentum in the world of business, that we could give credibility to untapped capabilities for new ways of thinking and interacting that enabled deep, collective learning, and that this credibility could eventually lead to partnership between the world of business and the world of education. I have seen the beginnings of this develop spontaneously in many settings, where, after working for five or ten years, people who have started to develop a different way of working together look around and say: What about the kids? How will this affect the kids? How can these changes be extended into schools? I don't think we have to convince people that we all have responsibility for raising children. It's in us—personally, biologically. When people start to build a sense that they can shape the workplace in a way that represents what they deeply care about, they invariably start to say, "But what about the kids?"

Such partnership might bring new perspectives and capabilities to educators seeking to produce fundamental change in schools. What does it mean when you try to go from one or two people driving their agenda through a school or a school system to actually believing that the only agenda that really matters is the shared vision that emerges from us collectively? How do you create a harmony among different visions that aligns, organizes, and coordinates a diverse community? That is what building shared vision is all about.

In this context, it might be helpful to go back to what has been the cornerstone of my personal journey for almost 30 years and consider the title I was given to speak to today: Systems Change in Education.

The Systems Revolution: From Controlling Things to Understanding the Living

As someone who has lived with this notion of system for a long time, I would like to offer a few comments. System is a problematic word. Most of us have an evoked meaning

as soon as we hear that word. What comes to mind when we think of "system?" [Audience responses.] Big; Impersonal; Inertia; External forces; Stuff I have to comply with, work around, overcome, live with; "them" rather than "me." You can see why I say that system is a problematic word. I would not recommend using it to describe what you really care about, because most people will hear: Big, Impersonal, External forces, Constraints, Something that makes me *do* something but *doesn't enable* me to do something.

At this point, I'd like to weave a little different picture. For the last hundred years, a revolution has been occurring in our scientific view of the world, and for better or worse the term most widely used for this revolution is the systems revolution. It started in physics and carried into biology. My own background is in engineering, and it is definitely present there. The revolution is gradually working its way through all the sciences, and it will probably have a huge impact in our societies two or three hundred years from now because that is typically how long it takes for a major revolution in science to work its way into society.

We run our school systems today on principles from the 17th century. We have a very Newtonian world-view, and we all learned it in the same place—school, because school teaches what science says is the way the world works. This wasn't the case 150 years ago. In those days people didn't learn the Newtonian world-view. They might have read Ben Franklin's *Poor Richard's Almanac*, or learned about crop rotations, or whatever was relevant. They didn't learn that the world is made up of billiard balls bouncing off each other, and that the nature of science is to identify the forces that control things. They didn't learn that the purpose of understanding something is so that you can control it. People living on farms didn't think about controlling nature. They thought about working with nature. They didn't think about altering the seasons. They thought about understanding them. But today, we understand in order to control, because that is the Newtonian world-view.

The revolution that is now occurring in science can be described in different ways. Let me offer you my perspective. In some sense, science is an agent of culture, and it answers the question, "What is reality?" All cultures enmesh their members in these questions: "What is real?" "What does it mean to be alive?" "What does it mean to be a human being?" Today we look to science to answer these questions, and science is starting to come up with a rather remarkable set of responses. We no longer see the world as bouncing billiard balls. We no longer think that the most fundamental things are, in fact, things. And we are starting to see that controlling reality may not be possible in the way we once thought.

The emerging scientific world-view says something very different from the Newtonian world-view. It says that the fundamental nature of reality is actually re*lationship*, not *thing*. All these things that surround us, which our culture tells us are solid and hard, are 99 percent empty space! This thing that we call a body is, in fact, a process. It is continually replacing itself. Buckminster Fuller used to hold up his hand and say, "What is this?" Most people answered, "It's a hand." He would say, "You know what? Last night I went to bed with one and this morning I woke up with a new one." Now, I didn't get a whole new hand in one day, but I do get a whole new pancreas, and the hand completely replaces itself in a matter of months. I'm not talking metaphysics. I am taking about physical phenomena. As Bucky used to say, the hand is not a thing; it is a "patterned integrity." In a sense, our body does not "have a hand," but a capacity to reproduce hands. Things arise out of a deeper reality of relationships.

The emerging scientific world-view says something very different from the Newtonian world-view. It says that the fundamental nature of reality is actually relationship, not thing.

The revolution in science is gradually starting to address an age-old question that Western science has never dealt with much: What is life? What does it mean to say that something is alive? Probably the most compelling metaphor for the Industrial Age is the machine, because our scientific progress has manifested itself as an extraordinary ability to build more and more complex, sophisticated, remarkable machines. The problem is that when a metaphor becomes deeply rooted in the collective consciousness, we start to see everything like that, and before long we see *ourselves* as machines. We see our organizations as machines. And we see

our kids as machines. We see this way because Industrial Age science has taught us to see this way. I will come back to this.

So, we have these two notions of system: the Industrial Age notion of machine and the living system. And, we, and our kids, are caught between these two notions. For most of us, "the system" means rules, regulations, power relationships, organizational charts, things you do to get certified, and so on. But, then there is the notion of the living system. Consider this from a kid's perspective. Take biology for example. Biology changes incredibly for a kid when it shifts from being about memorizing, isolated facts about cell walls to understanding how a living cell functions, and how it interacts with its environment. The cell is the building block of all living systems. But we have studied living phenomena as if they were dead—isolated facts, fragments of information. Do you know why kids do not get excited about biology? That's why.

Several years ago, I met a woman who was trying to teach English literature in a high school on the south side of Tucson, a very poor area. She had to teach Shakespeare to Hispanic and Native American kids who were wondering how they would survive the next day. With her boyfriend, who taught science in another school and had developed computer simulation models of how cells worked that got kids totally engaged, she said, "Let's build a simulation model of Hamlet." The kids loved it. Suddenly Hamlet came alive. They could ask questions like: What if he hadn't done that? What if he had done something else? What might happen? A static thing became a living tapestry of people interacting with one another. I will never forget sitting around with some of those kids two years later, and listening to one boy, Raphael, tell me about what that computer simulation model of Hamlet had meant to him. "My brain popped open," he said. He rediscovered his music. We talked about the career he was making for himself as a musician, a career he had given up. These developments are always more surprising than we expect.

The Living System Called School

Something is different when we study things as if they are alive. A living system keeps recreating itself. When we apply this to schools and school systems, we discover that we have to keep asking: Why is the system this way? Why are the rules like that? You can't settle for pacifying explanations, like "the people who have the power make it that way." You must inquire more deeply.

A system has many levels. The most important levels are not the rules and the procedures but the thinking that lies behind them. When you start inquiring deeply into a system, you ask, "What assumptions do we never talk about—what assumptions represent the thinking that produces the procedures and the rules, and continually reinforce them?"

Inquiring into assumptions is tricky. You can ask people: What do you think about learning? What are your key assumptions about learning? The answers you will get will likely be those from textbooks. What we learned when we got our Ph.D. You will get the proper theories. Or, you can watch what people do. You must watch how the system actually functions, and then ask, "What thinking might lie below the surface that leads people to act that way?" Often, you will come up with interpretations that are almost diametrically opposed to what people say. You know that old saw, "I cannot hear your words. Your actions speak too loudly." That is how you come to understand assumptions operating in a living human system. You look at how the system is functioning, and what people are doing.

A few assumptions about learning and schools stand out to me. I offer these with humility, as a starting point for thinking, because your thinking is more important to you than mine is. Most of what I am going to say to you is from my experience as a parent, not as an educator. But as a parent, I see the system in operation and these assumptions are very real to me. Moreover, there is an internal consistency to these assumptions. They reflect the world-view of the Industrial Age.

Industrial Age Assumptions about Learning

The first key Industrial Age assumption is *the deficit model*. Conformity is a core value of the Industrial Age, and that's why this assumption is a cornerstone: things must be brought into conformity. Educators don't give speeches advocating the deficit model, but

every school child knows its sting. Children experience the deficit model as: "I'm not all right; there's something lacking with me; I don't have what I need to succeed in life." The way I have found it most powerfully articulated by kids is when they say, "They don't respect me." This is what the deficit model feels like, experientially.

A recurring problem in complex human systems is what Chris Argyris calls "undiscussability." This occurs when there is a deep problem but there is no setting, or permission, for that conversation to occur. Everyone is then stuck. Not only is the subject undiscussable, the undiscussability is undiscussable. This occurs, I believe, with the deficit model. Kids have no one to sit down and talk with about the disrespect they experience. It is very difficult for children to articulate to an adult that they do not feel respected for who they are. Moreover, they look around and see that everyone is being treated with more or less equal disrespect, and this makes it even harder to discuss. If a kid does say this, the teacher is likely to say, "Of course, I respect you"—and *you* could add, ". . . and that's why I don't listen to you." Our schoolroom theory of learning is based on the belief that children don't have what they need, aren't developed, aren't formed, aren't . . . in conformity to what society needs. And it is the school's job to fix this lack of conformity.

What is the alternative to this deficit model? We can start by questioning the related view that if there were no schools children would not develop. But nature knows how to develop. Left to nature's own devices, development occurs. The real question is, "How does school add to the process?" Or do we systematically undermine the process?

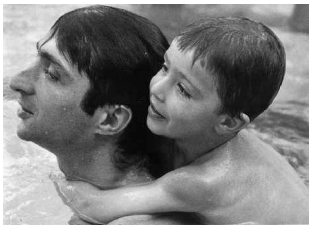
Do you think there is no education process in a tribal culture? No development? The tribal system of education, as it has occurred in indigenous cultures for tens of thousands of years, starts when a young person wants to learn something, so she goes and hangs out with the people who seem to know something about it. That's how it works. There is little evidence that people n*ever* learn anything, sit in a corner and expect the tribe to take care of them. Everyone seems to find a place, what he or she wants to learn about, where they can contribute. Now you might think that something that has been around for many thousands of years warrants being taken seriously, that we would look to understand how it works, that we would seek to improve upon it rather than disregard it and go off and create our own system from scratch.

But to take the tribal education system seriously, we would have to adopt the assumption that children are continually learning. You cannot keep learning from occurring. Learning is nature expressing itself in its search for its own development. It can't n*ot* occur. The core educational task is to assist, not replace, that natural learning process. The deficit model heads in the opposite direction. It assumes that something is broken and we need to fix it. It is a very reasonable way to think about machines. But not a very effective way to think about living systems. There is a second Industrial Age assumption about learning, and it is important that you see it as well.

The second assumption is that learning takes place in the head, not in the body. Indigenous cultures think that their knowledge is in their body, not in the head. We may have some ideas in our head, but that is different from knowledge. Knowledge is about the capacity to do something. Most of us know how to ride a bicycle. Very few of us know the theories of gyroscopic motion whereby the bicycle works. But we know how to ride a bicycle. We know how to talk. We think learning language is trivial, but it is an extraordinarily complex process. By comparison, most of what we learn in school is trivial.

Learning is nature expressing itself in its search for its own development. It can't not occur. The core educational task is to assist, not replace, that natural learning process.

This second assumption, that learning is in the head, is highly cultural, rooted in the European tradition of "the aristocracy" versus "the common people." Michelangelo could not have dinner with his patrons, because they were the aristocracy and he worked with his hands. This assumption that learning occurs in the head leads us to extraordinarily limited notions of development. This is tragic, because it is the musical, kinesthetic, interpersonal, emotional intelligence, as well as the abstract symbolic reasoning, that characterizes development. Each of us has different propensities. Some of us are brilliant in one area. But we all embrace the spectrum of intelligences. Not appreciating this leads schools, without necessarily intending



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it, to be anti-developmental. How many of you learned in school that you couldn't sing? How many of you learned in school that you couldn't draw or paint? How many of you learned in school that you weren't good in math? That you weren't good in English? That is the deficit model played out in the fragmented world-view that separates learning in the head from other learning.

Our cultural predisposition to see learning as occurring in the head also obscures the wholistic processes of genuine intellectual formation. I will never forget a beautiful story told by a retired chairman of the Physics Department at MIT. As a child, he said that one of his most vivid memories was of sitting underneath the piano while his grandmother played. He said he could still feel what it was like, as a three- or four-year old, sitting under that piano as she played Bach and the music washing over him. "That is when," he said, "I became a physicist." Cognitive development in the head? Nonsense.

The third Industrial Age assumption about learning is so obvious that we hardly need to elaborate it here. It is that there are smart kids and dumb kids, as opposed to just kids. It is opposite to the notion that all children are born with unique gifts, and the healthy functioning of any tribe is defined by its capacity to develop each gift. The assumption that there are smart kids and dumb kids is a byproduct of the machine age need to force nature's infinite variety to conform to a small set of pre-determined categories.

Industrial Age Assumptions about School

There are another set of transcendent assumptions that are embodied in the institution we call school, how it is organized and the way it does what it does. Like our deep assumptions about learning and the nature of human development, these assumptions—about specialization, the nature of knowledge, and stages and speed—are very difficult for us to see, because we have lived in the institution we call school for much of our lives.

The first assumption about school and how it works—not how it is espoused—is the classic Industrial Age management system, where you break all the jobs into pieces. You let somebody be a superintendent, somebody else be a principal, and somebody else be a teacher, and assume that is the right way to manage the school. You do not build partnership among those people, or a sense of collective responsibility. You build a sense that if each person does his or her job, then things will work out. It is the antithesis of a team. It is as if somebody in basketball thinks that if they rebound at the defensive end of the floor, the team will do fine—they don't need to do anything else. But they won't be on that team long, even if they are great rebounders, because everybody has to do a little bit of everything. Most importantly, we all need a real sense that functioning well together is paramount, because the child experiences the whole of the school not just the pieces. The Industrial Age management model breaks the system into pieces, creates specialists, lets everybody do their piece, and assumes that someone else makes sure the whole works.

In this system of management by specialization, the teacher is the local manager or supervisor. Her or his piece is to make sure the kid learns. Or, to put it bluntly, I make sure that the kid demonstrates to me whether or not the learning I am seeking has occurred. The kid's job in this system of specialization, as every kid quickly figures out, is to do everything he or she can to gain my approval. This is obviously a teacher-centered process. The teacher has the power to define. Not the kid.

The teacher-centered assessment process in school is increasingly anachronistic in an era where what matters is lifelong learning. Regardless of what people learn in school, to be successful in life people will need to keep learning throughout their lives. What do you think happens to people whose primary skill is pleasing a teacher, who then go to work and then become preoccupied with pleasing a boss? Are they good lifelong learners? Of course not, because a cornerstone of a lifelong learner is the capacity for rigorous, objective self-assessment, knowing how well one is doing. Developing the capacity for objective self-assessment is itself a lifelong learning process, one that is foreign to people whose primary skill and orientation is gaining the approval of their superior. But that is what the system of specialization in school produces.

Fragmented specialization appears to be a logical way to organize schools because of another Industrial Age assumption—the assumption that knowledge itself is fragmented, that knowledge arises in separate categories. Over here we have literature. Over here is

mathematics. Over here geography. The fact that life isn't quite like that, that life presents itself to us whole, that challenging problems are challenging because they have many interdependent facets, remains invisible to the fragmented academic theory of knowledge. Given this theory of knowledge, it comes as no surprise that the further an individual progresses in the formal system of education the narrower and narrower her or his knowledge becomes, finally culminating in the Ph.D.—or as we students used to say, "piled higher and deeper." This is the cult of expertise, people who know a lot about a little.

This deeply fragmented theory of knowledge is antithetical to a systems view of reality. The notion that reality is comprised fundamentally of relationships recognizes the inter-relatedness of things. Our education system does not do that. It tells people that what matters is how big your pile of knowledge is.

Thirdly, our system of education is based on what philosophers call naïve realism. Teachers do not teach as if they are communicating subjective views or interpretations of what happened. They teach as if they are communicating facts. Kids learn "what happened" in history, not an accepted story about what happened. A naïve realist is someone who thinks that "what they see is." We all live most of our lives as naive realists because the data of our senses present themselves to us with such compelling force. This is not a problem per se. The problem arises when we fail to recognize this.

What do you think happens to people whose primary skill is pleasing a teacher, who then go to work and then become preoccupied with pleasing a boss? Are they good lifelong learners?

Two Chilean biologists, Humberto Maturana and Francisco Varela, have developed a pioneering theory about how biological entities produce what we call cognition. A pioneering synthesis of biological and psychological science, the implications for human beings of "Santiago Theory of Cognition" can be summarized in the simple statement, "Everything said is said by somebody." No human being ever produces a definitive statement about reality. It's not biologically possible. Think about what that would mean in schools. Think of teachers who touched you as a student, not because they *knew* the answer, but precisely because they didn't know. Their curiosity inspired you, and their passion fired your imagination. They were so excited about what you might learn together that you loved them as teachers. You valued their experience. You knew they thought a lot, and you were interested in their thoughts, but they didn't give you the answers. When they told you, "This is what happened in history," they were really saying, "This is one view of what happened; here is something to think about."

Do you see how teachers operating as naive realists fits with the deficit theory of learning? The institution of school reifies the view that children are deficient by establishing a caste of experts who have *the* answer, teachers. In order to separate the teacher from student, to make one someone fundamentally superior and the other inferior, it is very important that the teacher must have answers, not questions. If all of us have questions, then we are all, ultimately equals.

The last assumption I would like to share with you concerns an overarching image of the school: school is a machine for producing graduates. If you think about it, school is probably the starkest example in modern society of an entire institution modeled after the icon of the Industrial Age, the assembly line.

For example, the system is organized in discrete stages, like any traditional assembly line. We call them grades. Everyone is supposed to move from stage to stage together. Each stage has a local supervisor, the teacher responsible for that stage. Probably the most problematic assembly-line characteristic is that school is designed to run at a certain speed. Every teacher knows what he or she has to cover this semester or this year. The machine has to go at that speed. Why is this? What is so magical about graduating from school at eighteen? I can't think of a single reason that makes a difference if a kid left school at fifteen, or sixteen, or twenty-five. But that is the way the assembly line is set to run, and everyone must move at the speed of the line, or they are in trouble.

And, of course, many kids are in trouble. Some kids seem to move more slowly than the assembly line. Today, they are called "learning disabled"—a machine definition that means, "does not move at the speed of the machine." We give them special treatment. Others move too rapidly, or just move too much. Frequently today they are diagnosed as

"ADD," Attention Deficit Disorder, another machine definition which means "does not pay attention to one thing at a time." These children threaten the ability of the local operator to maintain control at their stage of the process. Today, we typically put them on drugs. I must be careful with such statements. They may easily sound like unfair criticisms of teachers. I do not mean them as such. Our education system works the way it works because it is the way *we* want it to work. So far as I know, no school children are put on Ritalin, the drug currently being given to over ten million American kids diagnosed as ADD, without parental and physician approval. My point in citing these difficult and understandably emotional issues is purely to highlight machine-age thinking and its consequences.

In particular, I hope to get us to think about how much our assembly-line thinking forces us to treat the variety of human beings that nature creates as somehow aberrant because they do not fit the needs of the machine. I have a good friend and colleague who is an eminent economic theorist. He has contributed to particular ideas that have revolutionized certain aspects of financial management in firms. He has a son who has cerebral palsy. He and his wife have faced immense struggles with their son in school. They were told their son would need to be institutionalized, that he would never be able to complete elementary school, let alone high school. Today, he is doing his undergraduate work. He is now twenty-four, and is in his second year of college work. It has just taken him a little longer to progress. But the struggle they have had to go through! The only reason he has succeeded is that his mother has devoted her life to battling the educational establishment. The machine runs at a certain speed, and if you don't run at that speed, you don't fit into it.

The machine runs at a certain speed, and if you don't run at that speed, you don't fit into it.

Conclusion

I will leave with one thought about purpose. A machine has no self-determined purpose. Its purpose is that conceived of by its designer(s). What is the purpose of the machine called school? I encourage you to engage kids in this conversation—because it is almost impossible for you and me to have meaningful insights. We have been part of the machine too long. Ask a seven- or eight-year old. She will probably have fresh perspectives because she is coming from different experiences, a different world. Unlike a machine, a living system creates its own purpose. It discovers itself through reflection and heightened awareness, becoming aware of what it is doing and why. In social systems, this requires asking purpose questions together, especially including those less habituated to the way things have been.

If I had one wish for all of our institutions, and the institution called school in particular, it is that we dedicate ourselves to allowing them to be what they would naturally become, which is human communities, not machines. Living beings who continually ask the questions: Why am I here? What is going on in my world? How might I and we best contribute?

Commentary by Edward Joyner

More and more, I find myself wondering why educators and social policymakers do not embrace the work of Peter Senge.

I must confess, however, to some bias. Senge's work with organizations over the last three decades has paralleled our work with schools during the same period. Yet the current school reform movement still largely ignores systems thinking as a tool for transforming schools and school systems. School reform today is primarily school-based and confined to curriculum. Social policymakers and key decision makers do not seem to make the connection between school outcomes and the social, economic, and political environments in which schools exist.

I have experienced schools as a student, teacher, parent, principal, professor, and administrator of a national school reform program. I am convinced that virtually all schools succeed or fail according to their ability to move along the continuum of four themes that Senge describes in his ar-

ticle. These themes are: organizations as machines vs. living systems; fragmentation vs. relatedness; deficit vs. developmental thinking; and acceptance of what *is* vs. examination of *why* what is, is.

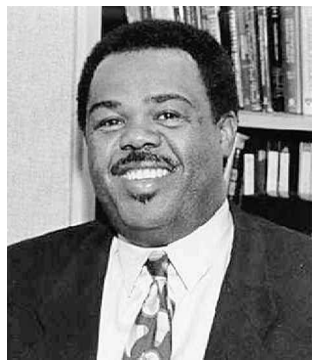
Educators can make a great leap forward by moving away from thinking of organizations as machines to thinking of them as living systems (able to self-correct). Senge's first theme suggests that organizations are dynamic systems capable of making changes that will move them closer to the goal of developing and educating all children to their fullest potential.

Senge's second theme, fragmentation vs. relatedness, allows schools to forge connections that make it possible to work across disciplines and roles to assess, plan, implement, and modify programs and activities that constitute the work of the school as it relates to staff, parents, and students.

Yet, if we do not embrace Senge's third theme, developmental thinking, we run the risk of becoming more efficient at miseducating children who enter school with great potential but little preparation for formal schooling.

Senge's final theme, rigorous examination of the assumptions that underlie our work, enables educators and parents to challenge any practice that seems to impede a child's growth and development. Lionel Meno, former Texas education commissioner, once said that "the only non-negotiable in school reform is the child's future." This brilliant educator was always willing to examine every assumption about schools and schooling, a practice that should be standard among those of us who serve children.

Wisdom is the righteous application of knowledge. By this standard, Peter Senge qualifies as a wise man. I hope that we can get beyond our national learning disability in education reform and use his tools to create a system where every child reaches his or her full potential.



Edward Joyner
Executive Director
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Commentary by Jay W. Forrester

In his paper, Peter Senge stresses the importance of systems thinking in education. Indeed, understanding systems is crucial to improving the organization of schools and to modernizing material that students learn. But how is one to think about systems? Our educational, social, and economic systems are far more complex than the technological systems faced by engineers. Even with the simpler systems of chemical refineries and space flight, an engineer would never try to design by simply thinking and depending on intuition. The engineer would use computer simulations to anticipate the behavior of a design, and would build prototype systems to demonstrate performance.

Without a foundation of systems principles, simulation, and an experimental approach, systems thinking runs the risk of being superficial, ineffective, and prone to arriving at counterproductive conclusions. Those seeking an easy way to design better social systems will be as disappointed, as if they were to seek an effortless route to designing bridges or doing heart transplants. Because there is no widespread realization of the complexity of social systems, people are easily beguiled into believing that systems thinking is sufficient.

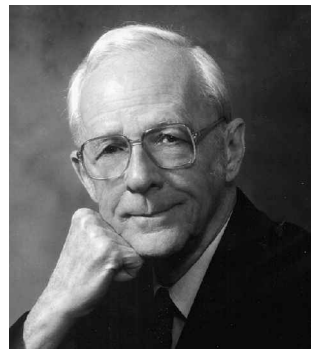
System dynamics is a professional field that deals with the complexity of systems. System dynamics is the necessary foundation underlying effective thinking about systems. System dynamics deals with how things change through time, which covers most of what most people find important. System dynamics involves interpreting real life systems into computer simulation models that allow one to see how the structure and decision-making policies in a system create its behavior.

System dynamics as a solid systems core is being pioneered in many schools.[1] In June 1998, there was a conference of 250 teachers in K–12 schools who are active in system dynamics. That is a large conference. I have never in my career been to a professional meeting where the morale and excitement about the future was so high. In schools where system dynamics is becoming a foundation that bridges across and unifies many traditionally separate subjects, teachers have frequently told me, "I had no idea that these students could do so much." My favorite sound bite from that conference was from the high school teacher who said, "The high school teachers who know what is going on here are terrified. They see the day coming when the elementary and middle schools will be delivering to them little MONSTERS who can THINK."

The excitement and promise of system dynamics in K–12 education is best conveyed by quotations from teachers who have experienced the impact on students:

From Tim Lucas, Superintendent in Ho-Ho-Kus, New Jersey:

> "We are introducing kindergartners to the concepts of stocks and flows and the idea that behaviors can be graphed over time. Beginning in first grade students are mapping larger sets of information and



Jay W. Forrester
Professor Emeritus, MIT Sloan
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working with causal loops to explain cycles in nature and everyday events. . . . By fifth grade, students are manipulating simple computer models that integrate into their curriculum."

Tim Joy at a high school in Portland, Oregon:

"I taught writing and literature for 13 years and always suspected I was party to some intellectual crime. Why is it that so many students thought the world of language began and ended at the door of the classroom? Then I discovered system dynamics. . . . System dynamics has a logic-based grammar, a universal language that students can readily learn and manipulate to create meanings. What have I found? Creating 'meaning' results in bolder QUESTIONS, whole new views which do not house traditional understandings."

From the report on a summer teachers' conference at the System Dynamics Group, Trinity College, Vermont:

"[System dynamics] models provide a common language with which to engage learners with diverse learning styles and interests. Simulations are especially engaging, and draw out many who might not otherwise participate in more traditional discussions and activities. . . .[System dynamics] models are extraordinarily powerful for helping to convert abstractions into concrete realities. A learner's ability to 'see' a system—what goes into a stock, where feedbacks exist—and then to run a model and ascertain how the system operates under varied conditions, renders abstractions into real meaningful, concrete terms. This discovery is true for students at all levels."

From Jan Mons, systems mentor to schools in Glynn County, Georgia:

"My most fruitful experiences occur when I discuss classroom discipline systems. We have both students and teachers build a discipline system together so that all parties will know what the system is capable of producing. When we do this many students have an 'Aha!' experience and state that they now understand how a teacher's frustration can accumulate over time. Teachers have their own insights as well—they begin to understand how they have often built discipline systems that were 'preprogrammed' to result in unpleasant situations."

Note

1. Material on system dynamics in K–12 education is available at the web site: sysdyn.mit.edu.

Creativity

by Surinder Deol

I need to break myself free
from the web of expectations,
rules of the game, so to say

Do this, not this
Speak but not too loud
Walk but don't run
Sing but don't disturb those
who are fast asleep

Laugh but not too loud
Climb high but not too high
Be kind to strangers, but not too kind

I need to change myself
I need to erase
a part of my personal history—
memories, influences of teachers
and caring mentors
I have to forget the convoluted pathways
of my own journey

I have to die every day to be born again—
vibrant, fresh and expandable
When I start this new life—
a life free of do's and don'ts—
I become creative

To be creative is natural
Creativity is not yours or mine
It's truly nameless—
true creativity is anonymous
To be truly creative we draw from a deeper well—
the well of shared consciousness,
where personal differences are meaningless
and where we are one as humans
and we create new images, new poetry,
we build new minarets for everyone to see,
to cherish and to be at home

True creativity has no cause and effect;
it's just there
We can own it or ignore it;
it does not go away
It stays like a musical note in the air
unseen yet vibrant when it hits our eardrums

Creativity is to ask for more—
more of us as humans
And the world we live in

It is about making demands
that can't be met
But when we have it
it is like having a sun
when a broken candle's light
was enough to look at ourselves in the mirror

Answer

by Judy Sorum Brown

You build a bridge
you are afraid to cross.

You start a sentence
which trails to a
question never finished.

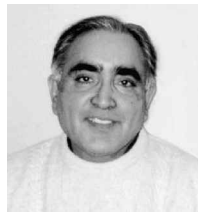
You sparkle like the
water in the sunlight and
then draw clouds around your
shoulders, and the light goes out.

You reach out in a thousand
genuine and human ways,
and then withdraw your hand.

Capacity to have
what you most dream of
is reflected in the
way your bridges,
light and questions
touch a human depth in others,
draw them to you.

My reaching out
to touch you is not
meant as a challenge to security.
It asks for nothing
but a noticing, receiving,
and acknowledging, as my
response to gifts that you deny
you have, yet say you want.
These startled consequences that
your unknown strength
brings to you—the deep connection,
human touch, the pain and joy—
are not an accident.

They are an
answer to the question
you are asking.



Surinder Deol
Senior Learning Specialist, Leadership Development Group
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Judy Sorum Brown
Educator, consultant, writer, poet

FEATURE

Strategic Alliances: Finding the Hidden Leverage for Success

Jennifer M. Kemeny and Joel Yanowitz

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Mergers . . . joint ventures . . . strategic alliances . . . businesses are increasingly relying on these activities for strategic advantage. All too frequently, however, the potential benefits fail to materialize. While much attention is focused on the financial and contractual aspects of an alliance, we believe that the key to organizational partnerships lies in a different arena. Increasingly we are convinced that the success of such alliances depends on the "human factors"—the ways that people think and interact. And we have gained practical insight into both the hurdles that impede cross-organizational alliances and the processes necessary for their success. But first, let's step back and take a "big picture" look at how alliances work.

A Systemic View of Alliances

Ironically, the degree to which human issues can undermine an alliance is directly proportional to the potential benefit of the partnership. This relationship makes sense if we consider why cross-organizational endeavors are attractive. Despite the important differences among mergers, joint ventures, partnerships, and alliances, all four are based on the assumption that there are benefits to closer working relationships with other organizations.

In a young business, performance may be directly related to the company's ability to perform core tasks, such as manufacturing a chip with a low percentage of rejects. However, once the product can be reliably constructed, the company can achieve greater benefits by improving the manufacturing function as a whole than by pursuing further production efficiencies. Imagine, for example, a highly efficient production line that nonetheless operates at a loss because poor production scheduling leads to shortages of raw materials and excessive personnel costs. Imagine a sales organization in which the salesforce has developed superb selling skills, but where orders are routinely mishandled. In these and other examples, improving the coordination of tasks in a function will yield greater benefits than fine-tuning each task separately.

Analogously, as functional effectiveness increases, the greatest opportunity for corporate performance improvement will come from cross-functional integration. Organizations worldwide are recognizing how departments that strive for their own optimal performance can combine to produce sub-optimal results for the business. A marketing function that achieves record-breaking revenues through customer promotions can nonetheless drive down overall profits through the extra manufacturing and distribution costs required to support those promotions. Similarly, marketing groups can inadvertently damage a company's image by making promises to customers that the R&D group cannot meet. Finance departments that institute hiring freezes to reduce costs can cause greater expenditures through the use of outside contractors.

In each case, the opportunity lies in coordinating and optimizing a larger system. Interestingly enough, the focus of management improvement trends in this century follows a similar pattern, from task efficiency to functional excellence to cross-functional integration. The logical next step is to conquer cross-organizational boundaries, that is, to align independent companies in the pursuit of joint goals.

While these alliances are a relatively new phenomenon, they can benefit considerably from the experience companies have had learning to work cross-functionally. It is fair to say that the issues experienced in moving from functional to cross-functional excellence apply to cross-organizational efforts—except that the difficulties are exponentially larger. Why so? *The fundamental challenge in integrating parts of a system is creating alignment among individuals and groups who see the world differently—who have different goals, norms, perceptions, and priorities.* The farther apart the groups, the more different their perspectives, and thus the greater the challenge in bringing them together.

The significance of these varied perspectives depends on the degree of innovation to which the alliance aspires. The simplest kind of alliance creates cost reductions through increased scale; an example might be a group of clinics that join together for purchasing discounts. This kind of alliance requires minimal change on the part of the participating organizations, and thus organizational differences aren't a critical issue.

A more ambitious aim is to improve operational effectiveness through closer coordination between businesses. For example, a consumer-products manufacturer that integrates its systems with its distributors can optimize loading and shipping operations. This kind of integration creates some challenges for the participating organizations, but since the innovations occur within established functions, there usually exist processes and expertise to manage the changes.

The greatest difficulty occurs when alliances attempt to develop significantly new ways of conducting business. Simply put, the greater the strategic benefit of an alliance, the greater the challenge of cross-organizational integration and the more critical the attention to human factors.

To understand the role human factors play in strategic alliances, let's look at the key obstacles to cross-organizational relationships.

© Emily Sper

Key Obstacles

Cross-organizational relationships must overcome three principal kinds of hurdles: coping with increased complexity, aligning contrasting orientations, and combining cultures.

Coping with Increased Complexity

The newly combined organizational system is by definition significantly more complex than either of its component entities were alone. Furthermore, no individual or group has experience working with the combined entity. Many organizations whose greatest skill is at the functional level find it difficult enough to manage the cross-functional repercussions of their own activities. These groups have not learned to think systemically and are thus beset by the unforeseen consequences of actions in other parts of the organization. Even organizations that have mastered cross-functional thinking will find it challenging to manage cross-organizational "ripple effects." The strong tendency to focus on maximizing gain for one's own organization can seriously undermine the broader effort.

Aligning Contrasting Orientations

Organizations' orientations can vary in terms of focal length (short-term vs. long-term), philosophical emphasis (strategic vs. operational), and integration of goals.

Anil Paranjpe
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Commentary
by Anil Paranjpe

That we are thinking about what is good about what could be thought of as the "soft side" of alliance-making is a sign of our times. It appears as if the world over, a quest for economic wealth is giving way to a deeper wealth that first and foremost acknowledges the centrality of the individual and the community. A lot has been written on the "new age." Maybe too little is being practiced.

This article is a good, deep look at what will make organizational alliances really work for everyone concerned. I have tried to compare it with a marriage. I do believe that most of us get married for a mix of reasons—some right and some wrong. The trick in marriage and all relationships actually lies in:

- Arriving at genuine understanding of why we are taking this step (getting married). Clarity of vision leads to deep-seated commitment.
- Acceptance of the fact that all of us evolve at different paces and in different areas, that life evolves and so must the relationship. What got us together may not keep us together. The key here is trust.
- Being vulnerable to hurt. Marriage is not about building a fortress around self, and making sure the partner doesn't take more than what he or she gives. In marriage, you are both willing to go repeatedly through the "crisis of emptiness," so that you both grow. We need time to discover our true nature, and the partner really plays (or could play) a vital role is showing us our true colors.

In marriage, the longer we stay together in the full sense of the word, the deeper and wider we grow—together. If we believe that love is about taking responsibility for others' growth, then we see our "fights" and "disagreements" differently. We keep the "system" in full view, and don't dwell on its parts for too long.

Some marriages last a lifetime. Some alliances do, too. But longevity is not the purpose—growth is. Growth in the fullest sense of the word.

Short-Term vs. Long-Term Focus

The delicate balancing act of addressing short-term needs while investing in the long term is never easy. However, through experience most businesses learn to walk that tightrope. Unfortunately, in an alliance each partner must consider how its short-term actions will affect the other's long-term success. The greater the potential benefit in an alliance, the more the participants' short-term and long-term fortunes are coupled. Often actions that make perfect sense in the short term end up producing the unintended consequence of undermining the long-term value of the relationship.

For example, a Fortune 500 office products manufacturer sought to have greater influence and merchandise share with its independent dealers without incurring the cost of an owned dealer network. It developed a potentially powerful alliance concept. Selected dealers, while maintaining financial independence, would make a commitment to represent this manufacturer's products exclusively. In addition, these dealers would upgrade their facilities and services to complement the manufacturer's high-end image. In return, the manufacturer would offer sophisticated business advice and services to the dealers, including attractively priced credit. The net cost to the manufacturer was much less than acquiring the dealerships, and the dealers stood to benefit from the business expertise and financing of a major corporation.

At the time, Innovation Associates, a unit of Arthur D. Little, was consulting to the senior management team of the manufacturer. Among other work, we were exploring the implications of the alliance through computer simulations of future operations. We developed a simulation that allowed independent decision making by the manufacturer and the dealers. The management team divided into the two roles. All went well when the business environment in our scenario was friendly. But when the teams were faced with a simulated market downturn, the results were sharply different. The immediate reaction of the "manufacturer team" was to protect its current margins by raising prices to the dealerships and cutting back on dealer support programs. The "dealership team," faced with declining profits, reduced investment in their facilities and in local marketing programs. In the simulation, the long-term effects of these actions hurt both groups—and generated significant ill will. Despite this preview of possibly negative consequences, the manufacturer chose to proceed with the alliance as planned. Unfortunately, the simulation results were mirrored in the real world, and the alliance concept fell far short of its potential.

Strategy vs. Operations

Individual organizations can sometimes function effectively despite having divergent operational and strategic goals. However, the success of an alliance may depend on the degree to which these very different orientations are integrated. Alliances frequently form because of the theoretical strategic advantage of envisioned joint capabilities. However, once the alliance is in place, those theoretical capabilities must quickly become real—and successful. Otherwise, the alliance is likely to fall apart.

Why are human factors such a critical element in integrating strategy and operations? Because in most organizations different groups are responsible for these two perspectives, and these groups do not combine their respective knowledge when making decisions. The strategic thinkers may have a clear picture of the long-term business opportunities, but will tend to underemphasize the difficulties of actually implementing new capabilities and the ways that alliance activities might hurt the existing organization. On the other hand, the operational team, motivated by incentives to improve current performance, will focus on the implementation challenges and will be less aware of or interested in the strategic possibilities. Thus an all-too-frequent scenario for an alliance is that senior managers enthusiastically create a grand vision while "leaving the details to be worked out by others." The subsequent operational decisions cause tactical improvements that don't add up to the strategic potential.

Differing Goals

A prevailing management paradigm is to "divide and conquer." We expect to reach high-level goals by achieving multiple, parallel subgoals, for example, by independently maximizing revenues and minimizing costs to generate maximum profits. This is a major cause of the phenomenon described earlier—locally optimized performance with sub-optimal results overall. In addition to problematic business results, this approach causes an increasingly myopic orientation—each group concerned with its own goals, which are viewed as the key to organizational success. Gradually these subgoals stop being the means to an end and become the end itself. Once a group unconsciously assumes that its goals are paramount, several undesirable tendencies may develop. At best, the group will make choices with little thought to the impact on other areas. At worst, there may be significant conflict between groups. (This is so common that newly appointed managers routinely inquire whether they are faced with "warring tribes!") Clearly, warring tribes cannot achieve the seamless integration needed to create strategically significant innovations.

It is advisable for all organizations—and essential for cross-organizational alliances—to replace the paradigm "divide and conquer" with "connect and comprehend."

Exacerbating the difficulty is the real likelihood that the alliance partners will have different goals—and that neither partner will appreciate the implications of the differences. In one alliance we helped facilitate, between a manufacturer and its key distributor, each organization's profits were driven by fundamentally different factors and measured in different ways: one by volume and the other by return on capital. This difference had never been understood and appreciated, causing years of tension and conflict between the parties.

Remember: The difficulties in a strategic alliance are the same as those within individual organizations, only exponentially more complex. It is advisable for all organizations—and essential for cross-organizational alliances—to replace the paradigm "divide and conquer" with "connect and comprehend."

Combining Cultures

Companies that come together with a clean slate (i.e., with no negative preconceptions), but have different cultures, may quickly find that the variations in their behavioral norms will create a breeding ground for mutual misunderstanding, poor follow-through, and eventual distrust.

In one joint venture between a major consumer-products manufacturer and a small, innovative drug developer, cultural differences quickly caused conflict between the participants. The manufacturer had a well-established hierarchical culture. There were strict behavioral norms, appearances counted, and promotions depended on being the prime mover behind successful endeavors. The drug developer was a young company whose independent-minded staff was accustomed to working in an informal, nonhierarchical fashion. One immediate problem was lack of mutual respect. The consumer-product representatives, experienced in market issues, were appalled at the scientists' business naiveté, while the researchers were reluctant to be directed by scientific "neophytes." The problem was compounded by the need of each group's representatives in the venture to prove their contribution to the parent company, which made them aggressive in competing for leadership positions.

Consider the additional challenge of combining companies that have a prior working relationship. In this case preconceptions invariably exist. And as the two companies rarely have a common mechanism for airing and untangling grievances, these preconceptions may well be negative. Unfortunately, the significance of this issue rarely becomes apparent until the alliance is well under way, because the senior managers who have met with their equivalents for semi-annual discussions don't have the same awareness of intercompany problems as do the operating managers who have daily interaction.

The significance of historical baggage is most evident when the alliance partners have had a prior customer-supplier relationship. Such relationships, unfortunately, provide ample opportunities for each organization to confuse and disappoint the other. It is much less problematic when two companies with similar roles join together. Even prior competitors, such as British Petroleum (BP) and Mobil in their European joint venture, are likely to have less initial ill will than did alliance partners such as Procter & Gamble and Wal-Mart. The latter example is particularly instructive.

With more than $30 billion in annual sales, Procter & Gamble (P&G) is a global leader in consumer products. One of P&G's largest customers is the North American retailing giant, Wal-Mart. In the mid-eighties, relationships between the two companies were at an all-time low. The two companies were unintentionally locked in an adversarial cycle of deteriorating relations, as was typical of the relationships between consumer-products manufacturers and distributors at that time. P&G came to market with an array of promotions. Power-buying Wal-Mart, with its policy of everyday low prices, used the advantageous pricing of P&G's promotions to stock up at discount. Wal-Mart's buying skewed P&G's production schedules, cash flow, and, ultimately, bottom line. P&G responded with more promotions. Wal-Mart and its distributors countered with more forward buying, with the associated warehousing costs. Each entity chose the response that foreclosed the other's possibility of succeeding. Faced with an intolerable level of rising costs, P&G decided to meet the challenge head-on—and turn an "enemy" into an ally—by forging a strategic alliance with Wal-Mart.

Innovation Associates was invited to help reforge the relationship to one of trust and mutual benefit. The initial challenge was to align the operating team, composed of managers from both organizations, who openly expressed doubt about the integrity and competence of their opposites. In a workshop lasting several days, the team used systems thinking tools to build a shared understanding of the mutual consequences of their combined business activities. Managers from both P&G and Wal-Mart saw how each other's actions could be understood as reasonable, rather than as self-interested maneuvers. Aligned around a new definition of "win/win" strategy for both companies, the team made the commitment to implement a powerful strategic alliance. The alliance they forged has since become a much-imitated model for the industry.

This partnership was an excellent example of piloting strategy through an alliance and "organically" creating company-wide commitment. During the year after the initial workshop, the strategic alliance team worked with each brand group to arrange an unprecedented nonpromotion arrangement for P&G products to Wal-Mart. The results were so favorable that the policy spread—until P&G broke with the industry by discontinuing almost all its promotions. As a result, P&G reported significant increases in profitability.

Putting It All Together: A Roadmap for Action

You can dramatically improve your company's success with strategic alliances by paying attention to seven principles we find particularly critical.

Clearly Articulate Goals

Begin by clarifying your own goals and motivations. Although it may sound absurd, we have seen companies enter into alliances with little or no articulation of their long-term intent and with only vaguely defined measures of success. Every alliance needs a thoughtful and explicit rationale to guide its ongoing effort. The fundamental question is, "What existing or new opportunities could we realize more effectively by combining our capabilities with those of an appropriate partner?" A compelling answer to this question requires a deep understanding of your own company's strategic orientation, markets, and products, as well as those of your partner.

It is critical to think through the potential gains thoroughly, that is, to carefully examine the "business case" for the alliance. One alliance went exactly as envisioned—the supplier tested out new systems that significantly improved service to its customer—but at a cost that was prohibitive to the supplier. In the original conversations, the supplier had never stated that it needed a significant increase in business from its customer for the arrangement to be profitable.

Define both the long-term and short-term goals for each alliance. Successful alliances establish ambitious long-term goals with shorter-term milestones. They use the accomplishment of those goals to generate trust and confidence in creating longer-term opportunities that may require significant investments.

Select Appropriate Partners

One key criterion for partner selection is often taken for granted: Your partner must also be able to derive long-term advantage through the relationship. A critical early step in the selection process is to define an alliance that will be a "win" for both parties. Ideally, the win will become more significant over time. Alliances that aren't mutually beneficial may fall apart or focus solely on incremental, transactional opportunities, missing possible strategic gain. In contrast, when two potential partners work together to ensure that each understands precisely how the alliance can help the other partner be more successful, it builds trust and establishes a longer-term relationship to sustain the alliance through its inevitable ups and downs.

Other criteria may also be important in selecting a partner. Having an existing working relationship may be a good starting point, but it is not sufficient. Will your partner understand the far-reaching impacts of an alliance and be willing to work through systemic issues? Is your partner likely to be effective at cross-organizational issues (as evidenced by its cross-functional effectiveness)? Is the company able to learn from its own unsuccessful projects? Would you be comfortable revealing your business activities to this company and vice versa? Knowing the characteristics of a potential partner will steer you away from false starts.

Work at Both Strategic and Operational Levels

The ability to work simultaneously at the strategic and operational levels is critical to an alliance's success. An alliance must move quickly from defining high-level strategic intent to successfully implementing new services and activities , and from performing operational tests to reformulating strategy and tactics.

While an alliance may be championed by an individual, the management of an alliance cannot be delegated to one person in the organization. As pointed out earlier, successful alliances often require the active knowledge, expertise, and involvement of people from multiple functions, geographies, and levels in both organizations. Each alliance needs a representational team composed of players from both organizations to guide the effort and navigate the challenges of working in new and unfamiliar territory. The team should include people who are senior enough to have decision-making authority, as well as others tactical enough to be "hands-on."

The ability to work simultaneously at the strategic and operational levels is critical to an alliance's success.

Membership in the team may change over time as opportunities or projects progress. Great care should be taken to integrate new members of the team so that they understand how the goals and operating norms of this activity are different from those of their "home" organization. This does not happen in a 15-minute briefing; new members need to be given extensive opportunities to understand the alliance's purpose, let go of old mental models, and assume personal ownership of success. Shortchanging these activities has sidetracked a number of efforts we've studied, as new team members took on significant roles without understanding the context, direction, and norms of the alliance activities.

Create Organizational Alignment

Clearly it is important to create conditions so that the direct alliance participants can operate as an integrated team. Less obvious, but equally critical, is for other groups to support the activities and the needs of the alliance team. For example, a sales-driven alliance will not succeed if the operations function considers it a low priority to modify systems to support the new activities.

How can one work toward organizational alignment? There are two critical tasks: generating widespread commitment to the alliance objectives and removing barriers to supporting the alliance.

Employees not on the team often have little or no exposure to what the alliance is trying to do. Therefore they are unlikely to keep the alliance in mind when they plan and execute their jobs—and can inadvertently take actions that will impede the efforts of the alliance team. Recognize that creating organization-wide commitment to a new direction requires skill and sensitivity. In the office products example, the CEO used the "tell them and tell them again" approach, responding to all his employees' concerns with yet another explanation of why "his" strategy made sense and implying that they were lacking if they didn't see the obvious rationale. Not only did he fail to generate commitment throughout the organization, some groups secretly hoped the alliance would fail. For example, the product development and marketing groups seemed indifferent to the impact on the allied dealers when they introduced a line of inexpensive recycled products that could erode the market for the high-end line carried by the dealers.

A misalignment between existing organizational goals and alliance activities will create barriers even for staff who support the alliance objectives. For alliance team members who also have "day jobs," the tension is generally between current objectives, such as quarterly sales, and time spent on the longer-term alliance activities. Employees outside the alliance team may also be requested to support the alliance in ways that conflict with their normal objectives. Should a customer service representative who is requested to minimize his or her time per call take extra time for the nonstandard problems of an alliance customer? Should a researcher divulge highly confidential drug protocols to a joint developer?

In outlining the goals for an alliance, it's important to think about how those goals mesh or conflict with existing operational goals. One approach: gather a team and have them "walk through" likely scenarios to identify potential conflicts. Once goal conflicts have been identified, adjustments can be made. The more the alliance team strives to create results that are outside the status quo, the more they may need special dispensation, revised goals, and self-sufficient capabilities. A classic approach is to make the alliance team a virtual organization with its own goals and rewards. Unfortunately, this can exacerbate the sense of difference from the rest of the organization and create pushback.

Often one company takes a more active role in initiating an alliance and is therefore more prepared to grapple with the internal issues. However, it is important for all partner companies to be willing to address organizational misalignment.

Deal Explicitly with Conflicts and Culture Clashes

All great partnerships enjoy high levels of mutual trust. However, partnerships rarely begin with such high levels, and what trust they do have may even erode during their involvement.

Companies with different cultures (i.e., most partners) have different norms and expectations of how people should respond to each other. Behaviors that make perfect sense for people coming from a highly structured, hierarchical organization may seem ineffective or even irrational to people coming from an organization with an entrepreneurial, open culture, and vice versa. For example, a member of a company that expected its employees to return phone calls every two hours was taken aback at how infrequently his opposite in the alliance responded to his messages. From his perspective, this indicated a lack

of genuine commitment from the other company. His opposite, being part of a company that didn't depend much on voicemail, was astonished to find out that his trustworthiness had been questioned over such a "trivial" issue.

A common trap is to try to get off to a good start by avoiding or minimizing conflict and differences. Many people have an intuitive belief that the best way to solidify a partnership is to be very "nice" and keep the difficult issues buried, hoping the latter either won't emerge or can be dealt with more easily at a later date. *In fact, the opposite approach is critical to building trust.* As early as possible, hold frank discussions of past breakdowns and problems that may have created baggage or mistrust. A systems thinking approach can often help people see how they have unintentionally created difficulties for their partners in the pursuit of their own success. In addition to clearing the air, we have seen alliance teams use this technique to generate key insights into potential conflicts and breakdowns, which they were then able to address in advance.

A systems thinking approach can often help people see how they have unintentionally created difficulties for their partners in the pursuit of their own success.

Often the team will need to establish its own norms and practices as it begins to work together. This process can be frustrating and challenging, since these cultural mismatches may not be evident until they become visible through some clash or conflict in dealing with specific issues. This "culture gap" can be compounded by "business gaps"—different goals and perspectives among team members.

Invest time in building the team. Holding educational events early on in an alliance can bring people to develop a common understanding of the strategic and operational issues that drive success in each company, as well as some understanding of the unwritten rules that govern behavior. Establish ground rules for interacting with each other to create an environment in which conflicts and misunderstandings can lead to learning and problem solving, rather than blame and further breakdowns. Training in systems thinking, productive communication, and conflict management has been shown to be a good investment.

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Maintain Strong Executive Sponsorship

Alliances often take on lives of their own as success breeds new opportunities. Acting on these opportunities may require capital investments, modifications to company strategies, or actions that are outside the bounds of current corporate policy. These factors all call for strong executive sponsorship of the alliance. Maintain continuous communication with your executive sponsors, with a particular focus on sharing insights about new opportunities and company practices that may be impeding your ability to proceed. Executives should also ensure that the organization has effective knowledge-sharing mechanisms to gain the maximum benefit from the insights about products, customers, and market opportunities generated by the alliance.

To the extent that the alliance team is required to pursue strategies and tactics that are outside what is considered "normal" or "acceptable," executives will play a critical role in establishing different feedback, measurement, and reward structures for team members. This has been particularly important at the beginning of efforts, when team members may feel exposed or vulnerable, being part of a new activity that is unproved and may be regarded with skepticism by other parts of the organization.

Be Willing to Experiment and to Be Committed to Learning

Alliances create the opportunity for learning that can fuel future success. The first and most obvious area for insights is the viability of the business strategy that the alliance represents. Alliances are a golden opportunity to run controlled pilots of new products, services, and activities. However, a learning approach is essential. The only guaranteed result of a cross-organizational alliance is that it will not roll out as planned! The capacity to continually document, reflect on, and modify activities is a critical element in a successful alliance.

A second area for learning is the process of building and maintaining successful alliances. Design into your alliance-building activities a method for documenting and sharing key insights into process, structure, roles, and resources that can be applied to future efforts. In this way, successes can be reliably replicated, and setbacks and disappointments in a single effort can still create great value for your company.

A third, less obvious, benefit comes from the opportunity an alliance gives you to see your company as others see you. Practices and assumptions that you have taken for granted may get challenged. This can yield learnings applicable to the whole organization, not just its alliance efforts. In one recent alliance effort, a supplier's tendency to overcommit without follow-through—a tendency that was well understood and compensated for in the supplier organization—was seen in a much more critical light because of its negative impact on the alliance partner. Members of the supplier organization were motivated to understand and begin to address the underlying causes of this behavior throughout their organization.

A third, less obvious, benefit comes from the opportunity an alliance gives you to see your company as others see you.

As cross-organizational alliances become increasingly important elements of corporate strategy, mastering the ability to create and sustain these alliances may become a critical success factor for your organization.

Commentary by Linda Pierce

Linda Pierce
Executive Director to the Executive Leadership Team
Shell Oil Company

If you are a leader in the business world, chances are you are planning, implementing, or reacting to an alliance, merger, joint venture, or acquisition. This article by Kemeny and Yanowitz provides a framework for grappling with the challenging human dynamics that will either enable or undermine the success of your venture. In this commentary, I use my experience with a variety of ventures involving Shell Oil Company to illustrate how you can use this framework to plan your own venture and keep it on track.

For decades, the world of business has been designing and installing innovative structures to increase value. Over time, business goals have become more ambitious, and implementation challenges have become close to overwhelming. Earlier efforts at building interdisciplinary teams, cross-functional business processes, and structural consolidations can now be seen as "practice" for the "big games" of mergers, joint ventures, and strategic alliances. As the challenges in the business game, with its mega-global mergers and alliances, continue to increase, the advantaged players will be the players who learn from each successive level of experience. This article adds to our collective learning by highlighting best and worst practices from real business endeavors.

Kemeny and Yanowitz have reflected on their consulting experience, and offer valuable insights to those whom, by choice or otherwise, enter the game of alliances at any level of their organization. Whether an organization is in the planning stage or the midst of a messy implementation, the authors' insights are relevant. Their systemic point of view focuses on critical human factors by articulating key obstacles in the areas of increased complexity, aligning contrasting orientations, and combining cultures. They bring their story alive by drawing on their own experience of what has and has not worked. After articulating the challenges, they offer seven principles that business lead-

ers and practitioners can use to create their own framework for deriving benefit or value—from their ventures.

Read their article with head, heart, and spirit. Often when we are facing complex challenges and seeking our way clear of difficulty, we fall into the trap of seeing the problem as a purely intellectual head exercise. The rewards of any alliance will not be won without heart and spirit. The messy reality of organizational change has to do with real people in real day-to-day struggles doing the best they know how to do. Kemeny and Yanowitz consistently acknowledge the influence of pre-venture assumptions, mental models, and implicit values. From my experience with ventures involving Shell Oil Company, the success of a venture depends on a critical mass of people who choose to embrace a set of assumptions, mental models, and values in support of the venture's objectives. This involves a degree of personal transformation—sometimes minor, but often major. Personal transformation is a process that must engage our heads, our hearts, and our spirits.

The following are examples of how you can use the authors' framework of key obstacles and their roadmap of seven principles from several related perspectives:

- A guide in the early planning of a venture. Kemeny and Yanowitz give a heads-up preview of what will likely happen. Given your own specific context and objectives, what processes, structures, and systems anticipate and deal with the key obstacles? How will you recognize, and deal with, "the unforeseen consequences of actions in other parts of the organization?" How will you reorient the "strong tendency to focus on maximizing gain for one's own organization?" When short-term crises emerge (as they inevitably do), how will leadership maintain its resolve for the success of the venture?
- A resource for community building among key stakeholders, for example, in planning and conducting workshops with them. Kemeny and Yanowitz point out that successful alliances often require people from multiple functions, geographies, and levels in both organizations to work together. How will you achieve "alignment of contrasting orientations?" When organizational structures become complex, we tend to draw boundaries for clear accountability. How will you maintain accountability without encouraging a deadly "myopic orientation?" How can you "replace the paradigm 'divide and conquer' with 'connect and comprehend'?"
- A lens to anticipate the natural conflicts and culture clashes so that effective interventions can take place. The authors offer practical ideas for identifying potential conflicts. In my experience, this is more than half the battle. How will you recognize a clash when you are in the midst of one? What methods build trust and healthy conflict resolution?
- An ongoing, "sense-making" tool to guide the organizational learning process. As the authors so correctly admit, "the only guaranteed result of a cross-organizational alliance is that it will not roll out as planned." Creating ventures is an unfolding and organic process; a prescripted plan only lasts for a short time. Regularly using Kemeny and Yanowitz' seven principles to understand and make sense of the current reality at discrete points in time is a good diagnostic process. Venture partners who consciously build in the capacity for learning from experience will reap long-term benefits, even beyond their current venture. All too often, business leaders ignore this opportunity for organizational learning, or give it secondary attention. How will you focus your organization's learning? What do you want to learn? What structures and processes will you put in place to enable learning? How will you know what you are learning? In the first issue of *Reflections*, Russell Ackoff's article, "On Learning and the Systems That Facilitate It," and the commentary by William Altier, make a strong distinction between ventures that focus only on growth objectives and those that have primary developmental objectives as well. Ackoff's article is a good resource for this perspective.

Kemeny and Yanowitz offer some answers to critical questions about joint ventures and alliances. But more importantly, they encourage informed questions. In today's dynamic and complex business environment, leaders who stay present with the critical questions will be far more successful than those who operate as though they already have the answers.

FEATURE

Conversation with Gary Hamel

C. Otto Scharmer

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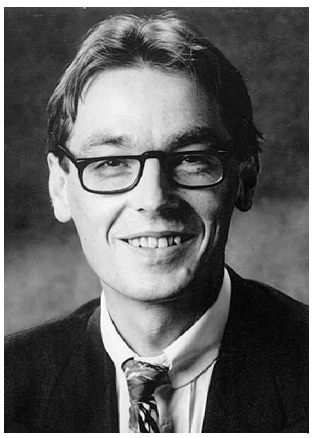

C. Otto Scharmer
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Gary Hamel is founder and Chairman of Strategos, Visiting Professor at the London Business School, and Distinguished Research Fellow at Harvard Business School. Hamel is one of the most influential thinkers on strategy in the western world. Along with C.K. Prahalad, he has been acclaimed for creating a new language for strategy and concepts such as strategic intent, core competence, corporate imagination, strategic architecture, and industry foresight. His work has changed the focus and content of strategy in many companies around the world. Besides his ground-breaking book, Competing for the Future*, Hamel has published nine articles in the* Harvard Business Review *during the past decade, seven of them with his coauthor Prahalad. This conversation took place on April 14, 1996 and was part of an interview series with 25 eminent thinkers in leadership and strategy sponsored by McKinsey & Company.*

C. Otto Scharmer (COS): What underlying core questions does your work address?

Gary Hamel: Like anyone in strategy, I think the underlying core question is how do firms succeed and how do they produce profit? I think more specifically in my work the fundamental question is how does a company prepare for the future and create inflection points in its strategy without the impetus of a crisis? How do you create revitalization in a company, but without waiting for a huge crisis, because most of the stories we have are stories of transformation and crisis? As one CEO takes it into crisis, a new leader comes and tries to save it. Jack Welch at GE tries to save a company from crisis. I'm not very interested in turnarounds or transformations. I think it's an old story; the recipes are very clear on how to do it. What is really interesting is how do you prevent companies from having those kinds of crises in the first place? I think to do that, you need a capacity for continual unlearning, and for continual learning about the future.

COS: Given this set of questions, what do you consider as your main findings?

Gary Hamel: First of all, I would not use the word findings to apply to my research because there is almost no empirical basis for my research at all, at least not in the traditional sense. I'm not an empiricist, I'm a theorist. I think about the way the world is put together. I don't do research in the traditional sense of big samples, but every piece of data that I come across, whether it is in the *Frankfurter Allgemeine Zeitung* or in the *Wall Street Journal*, I regard as data. It's all data.

I think what I have done is help develop a set of new lenses and new perspectives. I think it's much closer to the theory creation end than the theory testing end of the spectrum. For me, the most valuable research is not research that is well tested to the point of unequivocal findings, but research where people have exposure to a new lens.

If you look at what Peter Senge has done, he has developed organizational learning as a new lens. Thinking about the process of knowledge accumulation inside large enterprises is a new lens. What I have done in terms of reconceiving a corporation in terms of competencies, in addition to products and markets, is a new lens. That would be one contribution.

I think a second contribution is the sense that competition does not take place only within the product market domain. There is competition for foresight—to create a point of view about the future. There is competition to shape the evolution of emerging opportunity arenas. There is competition to attract and hold onto critical alliance partners and complementary resources that sit outside the firm. Ninety-nine percent of our view

of competition was competition within the marketplace with a price-setting mechanism and rivalry around customers and so on. And I think in many settings and in many industries, that is only a very small part of the whole competitive battle. Drawing attention to this would also be a contribution.

Another contribution is the concept of stretch. Vitality in an organization does not come from fit, and it does not come from equilibrium. This is now what people are also discovering in complexity theory. It is disequilibrium that creates growth and vitality. Creating misfit, lack of fit, or a gap between resources and aspirations is one critical precondition for corporate vitality.

Another contribution is pointing people's attention to the question of "how do you compete to shape the emergence of new competitive space?" It's what I call managing migration paths: forming coalitions, competing for standards, assembling complementary resources, building competencies, expeditionary marketing, experimental marketing. All of the things that are necessary to go from foresight to reality. So those are some of the contributions.

COS: What is the meaning of organization, and what is the meaning of strategy, and how do they relate to each other?

Gary Hamel: I think strategy is simply organized and purposeful collective action aimed at producing economic wealth and individual meaning. It is all about people and individuals in the organization. I think likewise the organization will not exist for long if it doesn't have some sense of purposeful direction. The great advantage human beings have is that we have an opposing thumb and first finger. We can actually change the environment around us and move things and create new things. But you have to have a point of view of what you want to create. To me, the lines between strategy and organization are so blurred. Or let me put it another way. The two concepts are so interdependent that for me it hardly makes sense to talk about the two as different things. They are the same thing in my mind. Now if you reduce strategy to planning, and if you reduce organizations to structures, then they are very different things. But if you think of strategy as essentially the process of accumulating new kinds of knowledge, and if you think about organizations as essentially a collective purpose, then the dividing line is not so clear.

To me, the lines between strategy and organization are so blurred. . . . They are the same thing in my mind. . . .

Over the last 10 or 15 years, strategy was much closer to marketing and economics. I think over the next 10 years, strategy is going to be much closer to organizational behavior and cognitive theory. That's a prediction, we'll see. But one of the problems is that a lot of the old labels don't serve us very well. Strategy implementation versus strategy formulation. Centralization versus decentralization. Businesses versus competencies. I think we have become prisoners of our own typologies and our own words. Part of what we tried to do in *Competing for the Future*, and will continue to try to do, was to invent some new language that transcends the old categories.

COS: You have expressed the notion of purpose. Would you regard an emergent concept of strategy as strategy at all?

Gary Hamel: We all know a strategy when we see one. I can point to Virgin Atlantic Airways and say they have a strategy, right? I can point to Swatch and say they have a strategy, and I can describe its elements and how they hang together, why it is internally consistent, and why it produces rents. And that's what we teach in business schools: "Let's decompose somebody's strategy and understand why it works." And that's what the five forces[1] allow you to do. They allow you, once you have an extant strategy, to understand what rent it's going to produce. We also understand planning as a process. But we know that planning does not produce strategy.

Henry Mintzberg has always been right on that point. Planning produces plans. Asking a planner to produce strategy is like asking a bricklayer to produce Michelangelo's Pietà. It's not going to happen. But it leaves us in a terrible quandary, because we can only

recognize a strategy after it has happened. And we have these elaborate planning processes, all of us knowing that they don't produce strategies. If you listen to Henry Mintzberg, he doesn't give you an easy way out of there. He talks about emergent strategies, but how do I increase the chances of strategies—interesting, robust, profitable strategies—emerging in the enterprise? Is strategy the product of somebody's indigestion where they woke up at two in the morning and got an insight? I don't know. The dirty little secret of the whole strategy industry, from business schools to consulting companies, is that we don't have a theory of strategy creation. We don't know where strategies come from. And I think the fundamental question is how do you increase the probability that good strategies will emerge? That to me is the question.

COS: What do you consider as the blind spot of the past strategy research? Would that be one of the blind spots, that there is no theory about strategy creation?

Gary Hamel: I think that is the biggest blind spot. That's the single biggest blind spot. We can evaluate strategies, *ex post*. We can give you the criteria by which you can make some judgments about whether they are profitable or not. We can turn the whole thing into an elaborate ritual called strategic planning. So I think that is a big blind spot, yes.

The other big blind spot has been the sense that somehow strategy is this thing that is independent from the dreams, the aspirations, the passions of individuals. To me that is another blind spot. And I'm sure there are a hundred more, but if they are blind spots, how do I know what they are? I have the same blindness. There are certainly an enormous number of intriguing questions that have yet to be asked. Most of these questions relate not so much to blind spots, but to emerging issues where we don't have good answers, like: "what does strategy mean when you have a coalition of firms and you have to create common purpose, not within one enterprise, but across multiple enterprises?" There are a lot of interesting unanswered questions, but if you had to say what are the two biggest blind spots, for me, one is around the theory of strategy creation, and the other is around the linkage—the nature of the linkage between the individual and the collective purpose of an organization.

The dirty little secret of the whole strategy industry, from business schools to consulting companies, is that we don't have a theory of strategy creation. We don't know where strategies come from.

COS: What would it take to develop a theory of strategy? I will indicate a possible answer from your writings. You make the distinction between three structural perspectives from which you can look at strategy. You used the metaphor of conception.

Gary Hamel: Gestation.

COS: Gestation and delivery.

Gary Hamel: And labor and delivery.

COS: I found these three perspectives very useful because they are a meaningful distinction of how you can look at different bodies of thought about strategy. Do you have more thoughts or considerations about how this distinction might play a role in a theory of strategy?

Gary Hamel: If you look over the last 10 or 15 years, most of what we've worried about in strategy would fall under the labor and delivery stage. It is understanding, in a reasonably well-defined extant market or industry, who captures the profits. A classic kind of example would be if you took Coca-Cola versus Pepsi and you asked, "Who makes more money in the soft drink business and why?" It's a very simple industry. You know where it begins and ends. You know who the players are. You know what the product is. The value-added structure is perfectly clear, right down to the last tenth of a penny. So that's easy. I think what you see today is a whole set of industries that are indeterminate. In

other words, the structure has yet to be determined, whether it is looking at data communications or satellite telephony or genetic engineering and so on.

The challenge is not to understand how you compete within an existing industry for share of profit, but how you compete for share of influence as new industries emerge. Is it going to go more Netscape's way or is it going to go more Microsoft's way? There's a huge competition for who's going to influence the pathways of that development. That's why I think there is a different set of mental models about competition that is required. Even before that, of course, is the question, "Where does foresight come from?"

The set of skills a manager needs when she or he is competing every day in the marketplace on price is very different than what she or he needs to speculate about where the industry could be 10 years from now. So there are different managerial disciplines at each of those stages that are required. I find the research on mental models particularly interesting when thinking about competition for foresight. I know mental models have a much broader application, but for me, their application is that every management team has a set of assumptions, biases, and prejudices about how their industry works—what customers want, what channels they use, what the value-added structure is, and so on. You cannot invent the future unless you can deconstruct those assumptions and biases. You cannot invent the future unless you challenge the existing mental models.

The broadest question for me is how do companies unlearn, and when do they have to unlearn? Lew Platt at Hewlett-Packard says, "The time you have to destroy the existing model is when the model is at the peak of its success." There are all kinds of reasons why firms find it very difficult to reinvent themselves at the peak of success. You might want to read Leonard-Barton's chapter on "core rigidities." One of those reasons is the mental models that people have. That's why I introduce the analogy of genetic coding—to say that it's as difficult for managers to change their belief structures as it is for individuals to change their genetic coding. But whether you call them managerial frames or mental models or genetic coding, it's the same thing.

So for me there are two interesting research questions or issues that come out. One is: What are the differences in the managerial capabilities you need in those different competitive domains? Can you find managers that can be equally good in all three domains, or is it an almost impossible task? The other very interesting question is: How do you examine and then challenge the mental models that you find within large companies?

In a successful company, almost by definition, three things become perfectly aligned over time. One is the belief structure people have about what drives success in this business. Second is the administrative system in the organization—how we reward, how we measure, and the information we use. And number three is competencies and skills and the whole value-added machinery. All those things become perfectly aligned, knit tight together. When a company finds that its existing business model is no longer working, it can neither change its administrative systems nor shift the competencies and the value-creating mechanisms without first of all deconstructing mental models. To me the question of mental models goes to the heart of strategy. Strategy is about taking apart and rebuilding people's mental models.

COS: I have one last question. How do you handle the role conflict with being a researcher and being a consultant, because obviously what would contribute to your success as a researcher, in terms of publishing, may be in conflict with your success as a consultant, or is that . . .?

Strategy is about taking apart and rebuilding people's mental models.

Gary Hamel: Well, I think this is a really good question, and I think it's not only me. I think that the whole dividing line between the university and the rest of the world in that sense is disappearing. The way I resolve it personally is that I make a distinction between concepts, methodologies, and tools. What I write about are the concepts. Where I try to invent and do things is at the level of methodologies and tools. The concepts are all in the public domain—you put them out to the public domain as soon as you go through the publishing process—but the tools and the methodologies are not. So it's a good question.

I think we are going to need to think about creating new kinds of organizations that are hybrids between universities and traditional consulting companies. Historically, the

view was: "You guys in the business school, 90% of what you do is irrelevant. Once in a while there is some interesting idea. All you want to do is publish papers—a maximum number of pages in journals read by a minimum number of people. You really don't care about capturing any economic value out of your ideas." Business schools have been forced to become more commercial. They want to be more profitable, and they compete for faculty. They have to worry about how they can hang on to more of the economic value of their ideas. I think there is a lot more competition today, at least at the margins.

What has been very interesting for me in moving to Northern California is the number of what I would call either quasi-university or quasi-consulting firms—they are really neither one—but there are an enormous number of institutions that are finding the white space between consulting and academia. Examples like the Global Business Network, like Institute for the Future, Grove Consulting, and the like.

COS: It's a whole new domain that is emerging.

Gary Hamel: Exactly, and my guess is that new domain is slowly going to pick away at both the revenue and the stature of both universities and consulting companies, because like almost everything in life, the real value exists not in the pure models and the archetypes. The real value exists in the synthesis and the people who can manage across those boundaries.

If you look at Institute for the Future, GBN, The Alliance for Converging Technologies, why is it that these guys get the access they do, and the level of influence they do? Because their motivations are not purely commercial. There is a learning side of it, there is a dissemination side of it, and they can manage the tension between responsibility for dissemination and responsibility for learning.

COS: That really addresses the tension between business interests and research interests. So would you argue that as a consulting company, the more you commit to research, the better?

Gary Hamel: To put it in very crude terms, the dilemma is that for most people writing in business schools, they have never applied the test of relevance. The defense of the business school has always been, "I'm not going to worry about what is relevant. Ultimately the marketplace will sort that out, and maybe it will be 20 years before somebody decides." So there is public funding for universities so an incestuous group of people can write primarily for each other, have fun, and not worry about relevance. But I think we're going to be able to afford less and less of that as a society.

The pathology on the consultants' side is that the consultants tend to be driven by the articulated problems of a client, whether or not the client understands the real problem—the deeper problem. In my work with companies I have never ever once been driven by the articulated problem of a company.

COS: Really?

Gary Hamel: Never once. If I have any value added when I work with companies, it's to help them ask new questions. It's not to answer the questions they have. Consultants answer the questions that companies have. "How do I take 20% of cost out? How do I shorten my product development cycle?" The rarest commodity of all is the new question. There is a saying that the highest form of teaching is to ask the new questions, not to provide answers to existing questions. Finding the answer is not the hard part, if you can articulate the question.

For example, I wrote that piece along with C.K. Prahalad on core competencies. We did the first draft of that sometime around 1987, and it was published around 1989 or 1990. I don't think I've given a lecture on core competencies in four years. I have no desire to spend five years of my life talking about how you evaluate them, how you find them, or what is the resource-based view. I know how to do that because I have some experience, but it's not very interesting. The interesting thing is what is the next question?

There is an analogy in product development. Most of the products that turn out to be the most valuable to us are products we never asked for. We didn't ask for the fax.

We didn't ask for the cellular telephone. We didn't ask for the videocassette recorder. No consumer research would have ever discovered those. How did they come to be? They came to be not out of market research. They came because you had some engineers who on the one hand understood what was technically possible, and on the other hand could look beyond the existing product concepts to deep underlying needs.

And I think it's analogous for people who want to do research in business on organizations or strategy or anything else. If you go out and ask companies what their problems are, you are never going to do anything worthwhile. Not seriously worthwhile. Not fundamental concept innovation. So I think the challenge for all of us is how we get a deep, intuitive sense of what the issues are that industry is wrestling with and how do we go beyond what often are very simplistic expressions of those issues by managers. In other words, what are the problems that they don't yet know they have? I never knew that I needed to be able to make a phone call from an airplane until somebody put telephones in all the airplanes. Now I can't imagine going for six hours without being able to make a phone call. So how do you help managers understand the real, deep down problems—even the problems and issues that they can't see—and how do you also give them enough time and enough freedom and independence for reflection?

We should be the discoverers and merchants of new lenses, new perspectives, asking new questions. Also, I think we have to worry about the dissemination of best practice, wherever that is. There is a huge societal contribution we make when we move best practice from good firms to mediocre firms, and we level the competitive playing field. More competitiveness, more wealth creation—and that is, in some sense, what consulting companies do. In fact, when Peter Senge creates communities of learning or when we do it in my company, we are transferring best practice.

So what I think is interesting in the OLC[2] model, and indeed with what I'm doing with my organization and what a lot of people are doing is that one, it's multidisciplinary and, two, it is essentially taking the ideas directly from universities into institutions. And number three, it is facilitating company-to-company learning. It is disintermediating consultants as the translators of academic research into practical tools. It is also disintermediating the consultants in their role as the conduit of practice from Company A to Company B.

COS: What is emerging now, whether you look at GBN or OLC patterns, is a new type of consulting that is facilitating or creating infrastructures where there are mutual cross-division and cross-company consulting processes.

Gary Hamel: Self-organizing communities of learning. I agree. And what the big consulting companies who have hundreds of bright, young MBAs have to ask is how do you make money out of that, and they don't know. Anyway, that's a different question. That's for another conversation.

COS: Thank you very much.

Gary Hamel: It's a pleasure.

Notes

1. The five forces are one of the two most famous strategy frameworks by Michael Porter. According to Porter, the five forces determine industry profitability. They are: suppliers, buyers, potential entrants, substitutes, and industry competitors.
2. The former Organizational Learning Center at MIT, now the Society for Organizational Learning.

Work-Based Learning: The New Frontier of Management Development, Joseph Raelin, Prentice Hall Business Publishing, 1999

Review by Barbara Lawton

Any new field of exploration or study begins with work on the fringe, where there is demand for solutions to new problems. New approaches are invented here—created on the shoulders of what has come before, in a new context. The field and its methodologies emerge and grow in an organic fashion, according to their usefulness, until a full palette of mechanisms or approaches has been created. To me it is a sign of maturation when the separate and disparate approaches of a newly emerged field can be brought together in a coherent framework that makes sense of the similarities and the differences among the varied approaches. This is what Raelin's framework, entitled "work-based learning," has to offer. Work-based learning is characterized as those "developmental activities and educational efforts within the organization (that) help it establish a culture of organizational learning." It is a structure that integrates organizational learning practices—such as action research, journalizing, and communities of practice—with theoretical concepts—such as, tacit versus explicit knowledge—into a coherent and seemingly useful framework.

His work-based learning framework is built in three dimensions. The first dimension covers the two modes of learning, theory and practice, which have, in Western tradition, been kept quite separate from one another. The second dimension covers the forms of knowledge, namely tacit and explicit. This two-by-two structure reflects the domain of work-based learning at the individual level and is populated with four individual learning types—Conceptualization, Reflection, Experimentation, and Experience. These four types track closely with Kolb's well-known learning style inventory. Like Kolb, Raelin contends that individuals are predisposed to a learning type, though all four types should be used to engender full learning.

This framework of individual learning is then extended into the collective learning domain, and four parallel learning types—Applied Science, Action Science, Action Learning, and Community of Practice—are created. In a discussion of each collective learning type, the author reviews the contribution of each type to work-based learning, covering its theoretical and practical history, and offering examples of its application. As with the individual learning types, these collective learning types should be used in concert for robust learning.

Through a detailed description of the collective learning types, Raelin reviews and categorizes most of the popular vehicles of organizational learning—such as learning histories, open space, and dialogue—bringing new insight to familiar approaches. Seeing these approaches in an integrated framework, which is grounded in an already familiar individual learning type, could be of tremendous value to a group interested in assessing its own overall approach to organizational learning and identifying opportunities for enrichment.

The second half of the book is dedicated to the practice of public reflection, that is, reflective practice in the collaborative domain. Reflection is concerned with the "reconstruction of meaning," and it's Raelin's belief that public reflection "illuminates what has been experienced by both self and others, providing a basis for future action." Public reflection is thus the means for collective double- and triple-loop learning.

Following an introduction to public reflection, the author reviews specific practices, some of which are common to most organizations, such as developmental planning and developmental relationships (e.g., coaching). I found his recounting of these common practices extremely useful in that he gives insight as to how they can be utilized for public reflection. In the reality of fast-paced organizations, it may be easier and more effective to enhance existing practices deliberately than to introduce totally new practices. In fact, this is the essence of work-based learning.

Raelin continues with an informative review of the important role facilitators, project sponsors, and project managers play in driving and supporting public reflection in action projects. Here again the author brings together the vast body of literature on teams and facilitation, integrating the pieces into a coherent whole. He offers concrete guidance and uses numerous examples to illustrate his points.

I believe this book is an excellent resource for chief learning officers, facilitators, and practitioners in learning organizations. By bringing forward a cohesive theory and providing detailed descriptions of how different methodologies complement one another, the author brings an important component to the reader's own, individual work-based learning process.

Process Consultation Revisited: Building the Helping Relationship, Edgar H. Schein, Addison-Wesley, 1999

Review by Stella Humphries

In his *Process Consultation Revisited: Building the Helping Relationship,* Ed Schein builds on and incorporates much of the material from his two previous editions of *Process Consultation*. However, in this small and succinct volume, he has completely reorganized the material around the primary theme of giving and receiving help. The capacity to be helpful is the central requirement for being a good consultant. To be truly helpful first requires the establishment of a certain quality of relationship—a quality that allows the consultant and the client to work together to diagnose the situation and find the remedies.

Schein has taken great care to give us a lucid and comprehensive entree into the philosophy, theory, and methodology of process consulting, emphasizing the face-to-face and small group setting. The inherent complexities and subtleties of deciphering the invisible forces of human affairs—that is, the inter- and intra-psychic and the cultural dynamics—is an enormous challenge. Schein pulls together key concepts and models that bring some order into the non-linear and intangible subject matter without resorting to technical jargon or oversimplification. He has distilled a lifetime of personal and professional experience into a book useful to a wide audience, including managers, teachers, coaches, and therapists—anyone who wants to be helpful.

Schein contrasts and compares process consultation (PC) with the expert (selling and telling) and the doctor-patient models. The main point of contrast is that the PC jointly diagnoses with the client and passes on the skills, that is, "instead of giving people fish, teach them how to fish." Schein laments that the consulting profession has not learned the

simple truths of helping, and that it does not use the lessons from the fields of psychotherapy, social work, coaching, etc. Business consultants, in his experience, all too often come in as the "expert" selling a professional service or as a "doctor" who not only makes the diagnosis, but also prescribes and administers the remedy. Despite the fact that a great deal of money has been spent, little is accomplished.

The book begins with an introduction to and definition of process consultation. Schein introduces the ten principles of process consulting beginning with: "Always try to be helpful." The author analyzes and explores, step by step, the psychodynamics of the helping relationship—that is, the subtle, invisible force of feelings, needs, and stereotyping of both the client and the consultant—which profoundly affect the attitudes, quality of understanding, and efficacy of the working relationship. He presents ways to deepen the relationship through the two primary skills of active inquiry and listening.

Part II of the book is devoted to "deciphering the hidden forces and processes." I found this part of the book particularly helpful. It offers a succinct overview of some useful models for making sense of "what goes on beneath the surface" as people interact. Part III moves on to an analysis of "interventions in the service of learning." Here the author reviews the emotional issues that every person faces in a new group situation, such as the problem of identity, influence and power, needs and goals, acceptance and intimacy. By identifying and unpacking some of the complex and interwoven aspects of personal and group issues, behaviors and structures, the author provides a map from which the consultant can make decisions about what to observe and what kind of intervention would best serve the primary task of the group.

Part IV, the final section, deals with PC in Action (that is, entry into the client system) and has very practical advice on establishing the formal and the psychological contract.

The book is organized around a conceptual core augmented by case studies and suggested exercises. The text is also peppered with many references for further study. Despite the simplicity of the language and my familiarity with much of the content, I could only read a few pages before I had to put the book down to digest the embedded meanings and implications. One has to persist in reading it. The book came to life for me after a direct experience—there is no substitute for it. Attending Schein's Managing Planned Change course at MIT gave me a visceral understanding that no amount of reading or theorizing could ever provide. I vividly experienced the resistance, which comes from even small and inadvertent lack of attention to what the "client" needs and the consequences of not attending to some of the basic principles of the helping relationship.

This is a book that ought to sit not only on every consultant's bookshelf but also on every manager's shelf. At the very least, the book can be used to recognize the characteristics of a good consultant and to help establish a satisfactory client-consultant relationship. The larger gift of this work, I believe, is its potential for cultivating the side of us that is "responsive and responsible" in our daily interactions, for helping us see the invisible and to dance with those forces instead of having them sabotage us. Instead of over and over entering into externally driven change programs that bring disappointment and often, pain, we can learn to bring a quality to our relationships and ways of working together that is the foundation for any meaningful change at the personal, group, or organizational level.

Book Announcements

Disappearing Acts: Relational Practice, Gender, and Power in the 'New' Organization, Joyce K. Fletcher, MIT Press, 1999

In this book Joyce K. Fletcher presents a study of female design engineers that has profound implications for attempts to change organizational culture. Her research shows that emotional intelligence and relational behavior often "get disappeared" in practice, not because they are ineffective but because they are associated with the feminine or softer side of work. Even when they are in line with stated goals, these behaviors are viewed as inappropriate to the workplace because they collide with powerful, gender-linked images of good workers and successful organizations. Fletcher describes how this collision of gender and power "disappears" the very behavior that organizations say they need and undermines the possibility of radical change. She shows why the "female advantage" does not seem to be advantaging females or organizations. Finally, she suggests ways that individuals and organizations can make visible the invisible work—and people—critical to organizational competence and transformation.

All Hat and No Cattle, Chris Turner, Perseus Books, 1999

Are "knowledge-work," "empowerment strategies," and "continuous improvement" making your head spin? Have you heard "let's get everybody on the same page" just one time too many? Was the latest management training just another dose of warmed-over dogma? Then it's time to start kicking up some dust and make a difference. *In All Hat and No Cattle,* maverick consultant and writer, Chris Turner, serves as our guide, and with a healthy dose of Texas humor and the wisdom gained from experience on the front lines, she exposes much of what passes for management wisdom as baloney and offers alternative ways of thinking about organizations and the people who bring them to life.

Dialogue and the Art of Thinking Together: A Pioneering Approach to Communicating in Business and in Life, William Isaacs, Bantam Books, 1999

Modern conversation is a lot like nuclear physics, argues William Isaacs. Lots of atoms zoom around, many of which just rush past each other. But others collide, creating friction. Even if our atomic conversations don't turn contentious, they often just serve to establish each participant's place in the cosmos. One guy shares a statistic he's privy to, another shares another fact, and on and on. Each person fires off a tidbit, pauses to reload while someone else talks, then fires off another. In *Dialogue and the Art of Thinking Together,* Isaacs explains how we can do better than that.