Information Systems Engineering for Organizational Effectiveness

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We describe some of the major needs for information technology and information systems in enhancing organizational effectiveness. To do this, we first describe several different views of organizations and how organizational information contributes to, or detracts from, organizational learning. Important in this regard is the critical use of information technology and organizational information systems to enhance the ability of organizations to move from reactive approaches to management and quality to interactive and proactive approaches. We examine organizational learning and organizational cultures and posed the claim that appropriate information systems engineering supports the development of a learning culture. This led us to examine, briefly, contemporary developments in organizational networks and the critical role of information technology and information systems in supporting human networking for enhanced organizational productivity. This leads to a consideration of reengineering efforts for enhanced organizational productivity. We note that information systems engineering efforts may be realized at the levels of product or systems, processes, or systems management. A major need in determining the most worthy mix of efforts at these three levels is determination is the most appropriate requirements for effort at each level. Some of the many ingredients that must be considered to evolve appropriate information systems are identified at the conclusion of this overview and perspective oriented paper.

1. Introduction

Individual and organizational productivity are major issues in much, if not all, of the world today. There has been much related discussion of the role of information technology and information systems in supporting engineering and reengineering of products and systems, processes, and management strategies for enhanced productivity. This paper, based upon contemporary

works of the author⁽¹⁾⁽²⁾, provides a systems engineering perspective on information systems - or an *information systems engineering* perspective - for organizational productivity.

2. Diverse views of organizations

There have been a plethora of studies of organizational leadership, organizational design, planning and human performance in organizations. Among these are such very classic and excellent works as the organizational studies of March and Simon⁽³⁾, the organizational design studies of Galbraith⁽⁴⁾, the strategic planning studies of Ansoff⁽⁵⁾ and Andrews⁽⁶⁾, the organizational psychology studies of Leavitt⁽⁷⁾ and Schein⁽⁸⁾, the public sector efforts of Lindblom⁽⁹⁾ and Wildavsky⁽¹⁰⁾, and many others.

Organizations can be viewed as instruments designed to enable pursuit of well defined specified objectives. In this view an organization will be concerned primarily with four objectives⁽¹¹⁾: efficiency, effectiveness, flexibility or adaptability to external environmental influences, and job satisfaction. Four organizational activities typically follow from this: complexity and specialization of tasks, centralization or hierarchy of authority, formalization or standardization of jobs, and stratification of employment levels.

In this view, everything is functional and tuned such that all resource inputs are optimum and the associated responses fit into a well-defined master plan. This has led to the development of Theory X theories of management and revisions to accommodate various perceived limitations such as to result in Theories Y, Z, and W. It is of interest here to briefly summarize these developments.

The theory X organizational management efforts are generally associated with the early 20th century writings of the "father" of "scientific management" in America, Taylor⁽¹²⁾, who was primarily concerned with

factory production systems. There are six principles generally associated with this approach :

- (i) Segmentation of work planning, and the associated task scheduling from the actual execution of the work effort ;
- (ii) Determination of the most efficient physical movements necessary to accomplish a task, determination of the optimum allocation of rest periods such as to maximize worker efficiency, and very careful measurement of the time required to perform tasks ;
- (iii) Thorough design of the workplace layout, and identification of the best way to utilize workplace tools ;
- (iv) Utilization of productivity incentives, through a system of piece rates and bonuses, to encourage high worker productivity ;
- (v) Establishment of authority and cooperative relationships between workers and management that allowed workers to be considered as individuals while conforming to task requirements at the same time ; and
- (vi) Vigilant selection and training of workers, reward of the most productive workers, and discharge of unproductive or otherwise unsuitable workers.

The Taylor approach to management and associated quality control was later dubbed *Theory X Management* by McGregor⁽¹³⁾. Its basic premise is that management should monitor worker performance through frequent time and motion studies. With appropriate control, workers can become as efficient and predictable as machines. We might characterize Theory X as follows.

(1) The management of an organization is responsible for profit. The elements of profit are capital, resources, and people.

(2) It is necessary to direct and control people, who are fundamentally lazy.

(3) The major responsibilities of management are the direction of workers to insure that they fulfill their roles in the organization.

McGregor's belief was that humans are not as inherently slothful as these Theory X precepts would indicate and that they would respond better to management based on the Maslow hierarchy of human needs and associated interpersonal relations than they would on optimization of task performance exhortations. He proposed a *Theory Y*, that would replace external control of human behavior by three internal controls : self-control, self-motivation, and self-direction. There

are five precepts of Theory Y.

(1) The management of an organization is responsible for profit. The elements of profit are capital, resources, and people.

(2) People are basically motivated for success and are capable of assuming accountability and acting in a responsible manner. Management does not have to instill these attitudes in workers.

(3) Whether work is a source of satisfaction, and will be willingly performed, or punishment, and will be generally avoided, is a controlled variable for the organization.

(4) Most people will learn not only to accept responsibility, but also to seek it if the organization's structure and reward system is such as to encourage these virtues.

(5) The major goal of management is to empower people, to enable them to become committed towards organizational objectives, and to recognize and fully develop their inherent potentials consistent with support of the organization.

Others emphasized these points during the 1960s. Maslow himself⁽¹⁴⁾ evolved a Theory Y type management approach. In another seminal study, Herzberg⁽¹⁵⁾ identified 16 factors which affect job attitudes that promote organizational success. There are achievement, recognition, the work itself, responsibility, advancement, and growth opportunities. These reflect the top two elements in the Maslow hierarchy of needs : esteem and self fulfillment. Herzberg's other 10 factors were called hygiene factors. These factors, when they are unsatisfactory, lead to job dissatisfaction. They are company policies and administration, supervision, relationships with supervisor, work conditions, salary, relationships with peers, personal life, relationships with subordinates, status, and security. The hygiene factors reflect lower three elements in the Maslow hierarchy of needs : physiological needs, safety and security needs, and love and relationship needs.

On the basis of this and related research, Herzberg suggested 7 management principles, which he called vertical job loading, that would enrich jobs through improving motivation.

(1) *Remove controls while retaining accountability*, to increase the sense of responsibility and personal achievement.

(2) *Increase the accountability of individuals for their own work*, to increase the sense of responsibility and recognition.

(3) *Give workers complete "natural" units of work*

to accomplish, to increase the sense of responsibility, achievement, and recognition.

(4) *Increase the authority of workers for the activities they perform*, to increase the sense of responsibility, achievement, and recognition.

(5) *Make periodic reports, such as performance evaluations, directly available to workers, rather than only to supervisors*, to increase the sense of internal recognition.

(6) *Introduce and encourage workers to perform new and more difficult tasks that they have not previously performed*, to increase growth and learning.

(7) *Assign workers specific and specialized tasks thereby enabling them to become experts*, to increase responsibility, growth and advancement.

In addition, Herzberg cautions against what he called horizontal job loading efforts. He viewed these as challenges to increase numerical production amounts, adding one meaningless task on top of another one, and rotating assignments “horizontally” through a number of routine jobs, each of which are in need of enrichment. Ref. (16) reprints many of the earlier seminal works in this area, including the work of Herzberg. The works edited by Hax⁽¹⁷⁾ and Schein⁽¹⁸⁾ also contain a number of excellent discussions on these points.

One of the potential difficulties with Theory Y is that there is no explicit provision for dealing with conflict. This is less a problem in a Theory X organization, since organizational leadership can eliminate potential conflict quickly by getting rid of the disturbers of the peace. A Theory Y organization, by contrast, is adaptive and creative, and tries to increase individual initiative through interpersonal relationships. The resulting multitude of individual innovators tend to compete for power and resources, and the result is often a confrontational environment that is difficult to coordinate.

Theory Z⁽¹⁹⁾ was proposed to cope with this difficulty. Theory Z management stresses arriving at major decisions through a consensus based on shared values. Many ascribe the Japanese quality achievements to adoption of Theory Z principles⁽²⁰⁾ necessary to implement the Theory Z organizational philosophy.

(1) Know and appreciate the Theory Z philosophy.
(2) Audit the organization's existing management philosophy

(3) Define an appropriate management philosophy for the organization.

(4) Implement the new philosophy.

(5) Develop the needed interpersonal skills.

(6) Evaluate progress in adopting Theory Z.

(7) Involve the union, if any.

(8) Stabilize employment.

(9) Identify and implement a system for slow evaluation and promotion.

(10) Broaden the path of career development.

(11) Implement Theory Z programs at the lowest organizational levels first.

(12) Seek areas of continued improvement.

(13) Continuously develop wholistic relationships.

The Quality Circle and Company Wide Quality Control efforts in Japan appear to be roughly equivalent to Theory Z management. Actually, the *Company Wide Quality Control (CWQC)*⁽²¹⁾⁽²²⁾ concept in Japan involves 4 principles:

(i) Inclusion of quality-related efforts at all phases of the systems engineering lifecycle, not just the phase specifically concerned with system production;

(ii) The participation by all people in the organization in quality-related efforts;

(iii) Setting the objective of continuous improvement in quality; and

(iv) Careful consideration of the customers' definition of quality.

There are apparent consensus-based difficulties inherent in Theory Y and Z management effort. Boehm and Ross⁽²³⁾ have recently proposed a *Theory W* management theory to ameliorate these. The “W” in Theory W refers to “Win-Win” situations that enable the many participants in a systems engineering development effort each to “win.” The theory aims to be simultaneously: *simple*, by being easy to understand and apply; *general*, in addressing most technical, management, and human situations likely to be encountered; and *specific*, in providing useful advice to the situation at hand. The primary technique of Theory W is negotiations among stakeholders to convert “lose-lose,” or win-lose” situations into “win-win” situations.

Boehm and Ross recommend four precepts that have been identified by Fisher and Ury⁽²⁴⁾:

(1) Separate people from the problem at hand.

(2) Focus on the interest of the parties involved, and not on advocacy positions.

(3) Identify options that allow for the mutual gain of all stakeholders.

(4) Insist on using identified, objective, and explicit criteria for judgment and choice.

They also identify a three phase management process that may be summarized as follows.

2.1 Establish a set of win-win prerequisite for the development effort

(1) Understand the way in which people wish to win. Identify the key stakeholders, in particular the customer, and develop scenarios which indicate what each stakeholder would consider to be a winning outcome.

(2) Establish reasonable expectations concerning what can be achieved with the technology at hand and the humans involved. A major difficulty in this regard is the tendency for the systems management team to underestimate the costs and time required to field a system. Developing a reasonable set of tradeoffs between performance, including quality and cost and schedule is essential.

(3) Match the tasks of the systems engineering team to various win-win options.

(4) Provide a supportive environment, especially in the form of education, training, and support for the systems development program.

2.2 Structure a win-win systems acquisition process

(1) Establish a reasonable strategic system acquisition process and associated program plan.

(2) Use this plan to control the project.

(3) Identify and manage all risks in a win-win fashion.

(4) Maintain constant involvement of participants.

2.3 Structure a win-win system product

(1) Design the product for the user, that is developing a quality product that is service oriented, easy to learn and use, easy to modify, cost effective, and designed for human interaction.

Theory W's win-win approach is gaining considerable recognition, as evidenced by recent developmental efforts in the support technologies^{(25)~(28)} that might better enable it. One of the major purposes of Theory W management is risk management, a subject discussed in Ref. (1) and (2).

3. Organizational information and organizational learning

Clearly, organizations need high quality and trustworthy information in order to function well. Thus, there is much motivation for the development and use of organizational information systems. Keen⁽²⁹⁾, however, acknowledges four causes of inertia relative to organizational information systems.

(1) Information acquisition is perceived to be only a small component among many important

organizational tasks.

(2) Human information processing is experiential and relies on simplification.

(3) Organizational change is incremental and evolutionary, with large changes being avoided.

(4) Data are a political resource to particular groups as well as an intellectual commodity.

Each of these factors suggests problems in determining how information is processed by organizations. Thus, we see that information is a major concern relative to organizational efforts that also involve leadership, learning, and culture.

Tushman and Nadler⁽³⁰⁾ have developed a number of propositions, based on their own and others research that reflects various aspects of information processing in organizations. The general conclusion of these studies is that, in an effort to enhance efficiency, organizational information processing typically requires selective routing of messages and summarization of messages. In the classical normative theory of decisionmaking, it is easily shown that information about the consequences of alternative courses of action should be "purchased" only if the benefits of the information, in terms of precision, relevance, reliability and other qualities exceed the cost.

Feldman and March⁽³¹⁾ present an alternate point of view in their description of information use in organizations. Their discussions of information incentives indicate systematic bias in estimating the benefits and costs of information due to the fact that the costs and benefits do not occur at the same place and at the same time such that one group has responsibility for information use whereas another has responsibility for information availability. Also, people are prone to obtain more information than is needed since, under uncertainty conditions the post outcome probabilities of events that do occur will be judged higher than the prior probabilities of these events. This will suggest that less information was obtained than should have been obtained and will, typically, lead to incentives to obtain too much information.

Feldman and March also indicate that much of the information that is obtained is obtained for surveillance purposes to uncover potential surprises rather than to directly clarify uncertainties for decisionmaking. Strategic misrepresentation of information, due to interpersonal conflicts and power struggles, is a third factor suggested as decoupling information gathering from decisionmaking. In this case, information must be suspected of bias. Finally, information is a symbol which indicates a commitment to rationality. There are

many incentives to displaying the symbol even if it is not used.

An organization is normatively concerned with enhancing efficiency, effectiveness, and explicability relative to administrative, governance, leadership, and managerial functions. There are four generic approaches that can be taken in response to coping with organizational exigencies in pursuit of these attributes.

(a) An *Inactive* organization will attempt to avoid problems in the belief, or hope, that they will go away in a natural manner. If accorded sufficient protection from the external environment, such as guaranteed entitlements, survival is indeed possible in an inactive organization.

(b) A *reactive* organization is one which will respond to difficulties after they develop, generally using approaches that have worked well in the past. This may well be a proper response if the situation is one with which the decision maker is experientially familiar, and if the situation has been identified correctly. A reactive organization will be very conservative and risk averse, and will not typically anticipate crises or chaotic situations. These are organizations primarily concerned with their own internal environment and with its maintenance. An inactive or reactive organization will not be able to attend to crises, at least until after they eventuate, and will have persistence and survival as their highest aspiration.

(c) An *Interactive* organization is one that is concerned with its external environment. Such an organization will adapt to external change, at least at the level of symptoms. It will attempt to cope with crisis situations through the development of better responses to the external environment. The interactive organization may, however, fail to learn through their inability to anticipate future perspectives and thereby will also fail to fully align theories in practice to espoused theories. Thus, although an interactive organization might be able to respond will to crisis situations that impinge from the outside, it will not necessarily learn from so doing such as to make it necessarily better in responding to a new crisis that is of a fundamentally different type.

(d) The organization that accomplishes "double-loop" learning, such that it learns how to learn better, is a *proactive* organization. It is able to apply knowledge principles and future perspectives that enable it to thrive in the face of continual change, including change of a chaotic nature, through adaptive behavior to enable it to adjust its structure, function, and purpose as appropriate

for continued productivity through organizational learning how better to learn.

These four generic response types have been used, in part, as cultural characteristics that influence the design of higher educational decision support, and executive support, systems in Ref. (32).

Other recent efforts have been concerned with learning organizations. Learning involves the use of observations of the relationships between activities and outcomes, often obtained in an experiential manner, to improve behavior through the incorporation of appropriate changes in individual and organizational behavior. Thus learning represents acquired wisdom in the form of skill based knowledge, rule based knowledge, or formal reasoning based knowledge⁽¹⁵⁾⁽³³⁾⁽³⁴⁾. It may involve know-how, in the form of skills or rules, or know-why, in the form of formal reasoning based knowledge.

Learning involves: situation assessment, detection of a problem, synthesis of a potential solution to the problem, implementation of the solution, evaluation of the outcome, and the resulting discovery that eventuates from this. This is a formal description of the learning process. It is also the problem solving process and involves the basic steps of systems engineering.

While learning, as we have defined it, appears highly desirable; much of the individual and organizational learning that occurs in practice is not, however, necessarily beneficial or appropriate in either a descriptive or a normative sense. For example, there is much literature which shows that organizations and individuals use improperly simplified and often distorted models of causal and diagnostic inferences, and improperly simplified and distorted models of the contingency structure of the environment and task in which these realities are embedded.

Senge⁽³⁵⁾⁽³⁶⁾ has devoted major attention to design of what are called *learning organizations*. According to Senge, *learning organizations* are "organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together." Five component technologies, or disciplines, are suggested as now converging to enable this learning. These are:

- (i) Systems thinking;
- (ii) Personal mastery through proficiency and commitment to lifelong learning;
- (iii) Shared mental models of the organization

markets, and competitors ;

- (iv) Shared vision for the future of the organization ; and
- (v) Team learning.

Systems thinking is denoted as the *fifth discipline* and is the catalyst and “cornerstone” of the learning organization that enables success through the other four dimensions. Lack of organizational capacity on one of these disciplines is called a learning disability. One of the major disabilities is associated with implicit mental models that result in people having deeply rooted mental models without being aware of the cause effect consequences that result from use these models. Another is the tendency of people to envision themselves in terms of their position in an organization rather than in terms of their aptitudes and abilities. This often results in people becoming dislocated when organizational changes are necessary and this leads to disconcertment.

Each of the five learning disciplines can exist at three levels. These are termed : *principles*, the guiding ideas and insights that suggest practices ; *practices*, the existing theories of action in practice; and *essences*, which are the wholistic and future oriented understandings associated with each particular disciplines. These correspond very closely with the principles, practices, and perspectives we have used to describe approaches to knowledge and systems engineering.

Based primarily on works in system dynamics, an approach for the study and modeling of systems of large scale and scope ; eleven laws of the fifth dimension are stated. We restate these here.

- (1) Contemporary and future problems often come about because of what were presumed to be past solutions.
- (2) For every action, there is a reaction.
- (3) Short term improvements often lead to long term difficulties.
- (4) The easy solution may be no solution at all.
- (5) The solution may be worse than the problem.
- (6) Quick solutions, especially at the level of symptoms, often lead to more problems than existed initially. Thus, quick solutions may be counterproductive solutions.
- (7) Cause and effect are not necessarily related closely, either in time or in space. Sometimes actions implemented here and now will have impacts far away at a much later time.
- (8) The actions that will produce the most effective results are not necessarily obvious at first glance.
- (9) Low cost and high effectiveness do not have to

be subject to compensatory tradeoffs over all time.

(10) The entirety of an issue is often more than the simple aggregation of the components of the issue.

(11) The entire system, comprised of the organization and its environment, must be considered together.

Neglect of these laws can lead to any number of problems. Most of these are relatively evident from Senge's description and our interpretation of the 11 laws of the fifth dimension. For example, failure to understand law 11 leads to the fundamental attribution error in which we credit ourselves for success and blame others for our failures.

On these basis of these laws, several leadership facets are suggested. Leaders become designers, stewards, and teachers. These are especially important for learning organizations. Each of these leadership characteristics enables everyone in the organization to improve on their understanding and use of the five important dimensions of organizational learning. This is said to result in creative tension throughout the organization. Planning is one of the major activities of the learning organization and it is through planning that much learning occurs.

Others have expanded on these notions, in an excellent work, Garvin⁽³⁷⁾ indicates three pragmatic needs to bring about a learning organization in practice. He cites these in the form of three Ms.

(1) *Meaning* for the concept must be provided, in terms of an actionable, easy to apply, and well grounded definition of organizational learning.

(2) *Management* guidelines for practice must be supplied to enable operational activities as well as high aspirations.

(3) *Measurement* tools be provided to enable outcome assessment of learning activities.

These will enable the potential for improvement to be associated with the reality of improvement.

Five “building blocks” are suggested by Garvin. These are :

- (i) A systematic problem solving process,
- (ii) Experimentation,
- (iii) Learning from past experiences,
- (iv) Learning from others, and
- (v) Transferring the resulting knowledge throughout the organization.

The systematic problem solving process is particularly important here. **Fig. 1** illustrates a representation of the suggested process. We might associated a set of questions to be answered through the efforts associated with each step, illustrations of what to look for at each step,

Fig. 1. Generic systems engineering problem-solving process.

and an indication of what is needed to proceed to the next step of the problem solving process with each of the six steps of this problem solving process. Associated with these five building blocks are collateral efforts associated with fostering an environment conducive to learning, and opening up boundaries and stimulating the exchange of ideas. One of Senge's major claims is that these two efforts, when associated with the five building blocks and the three Ms, provide a solid foundation for any learning organization with a commitment to learning in order to enable continuous improvement.

4. Information systems and organizational cultures

There have been many studies of organizational cultures and a number of these are discussed in Ref. (1) and (2). Here we provide a brief commentary about some aspects of organizational cultures that relate directly to information systems efforts. Schein⁽³⁸⁾ identifies 10 phenomena that exist in a culture. One the basis of these and additional stability and integration requirements, he poses a comprehensive definition of group or organizational culture.

Group culture is "a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems."

There are three major elements in this definition: socialization issues, including the process of how one learns; behavior issues; and issues of subcultures, and the extent to which they will develop. From this perspective there are causal dynamics involved in culture and leadership. Leaders initially create cultures when

creating groups and organizations. Once a culture exists, it will determine the criteria for leadership. A leader in a dysfunctional culture must either change it, such that the group survives, or the culture will ultimately govern the leader.

Schein suggests three levels at which culture may be studied.

(1) At the unconscious level of basic underlying assumptions, there are often unarticulated belief, thoughts, and feelings that represent the ultimate top-level source for the resulting values and organizational structures and processes.

(2) At the level of espoused values, formal statements of organizational objectives, purposes, and philosophies may be found.

(3) At the level of artifacts, which are indicated to be comprised of organizational structures and processes, or functions, the organization attempts to implement its espoused values.

We can represent this lowest level of artifacts as two levels, one corresponding to process, or function, and the other corresponding to organizational structure, or the product of the culture. Fig. 2 presents our representation of these, now four, levels of culture.

We can most easily observe the cultural product that is embedded in an organization's structure. With potentially a little more difficulty, we can observe organizational artifacts as represented by processes, or organizational functions. It is more difficult to examine the espoused value for the organization, and even more difficult to determine the actual values from the espoused values. These actual values represent the basic and foundational assumptions that drive organizational culture. Fig. 2 illustrates our interpretation of four levels of organizational culture impacts. While it is more difficult to measure cultural facets at the level of espoused purpose and inherent values, it is important that this be done as measurements at the levels of process and structure will possibly allow for good inferences about espoused values but will not easily lead to information about actual values, except through observations of espoused values and the processes and structure implied by these, and the products of the actual value system in terms of processes, structure, and organizational products.

Schein identifies a five phase lifecycle of culture formation for purposes of survival in, and adaptation to, an organization's external environment. The ultimate accomplishment in this is internal integration of organizational processes and structural artifacts in an

Fig. 2. Illustration of four levels of organizational culture and associated influences.

effort to insure the ability of the organization to continue to survive.

(1) The organization develops a set of shared assumptions and understandings of the organizational mission and strategy that is appropriate for achieving fundamental objectives.

(2) The organization develops a set of shared assumptions about operational goals that will accomplish its missions and achieve its strategic objectives.

(3) The organization develops a set of shared assumptions about operational means that will accomplish its operational goals. Generally, this is reflected by organizational structures and the operational task control system.

(4) The organization develops a set of shared assumptions about the measurement criteria and the information systems that will be used as indicators of success in goal achievement, or lack thereof.

(5) The organization develops a set of shared assumptions relative to the corrective efforts that will be used when it turns out that the detection and diagnostic efforts in the previous phase indicate that goals are not being achieved.

Culture has an impact on leadership, and leadership impacts culture. Each of these influence the actual functioning of the organization. The actual organizational purpose, function, and structure are clearly functions of the espoused purpose function and structure. Further, the culture formation process occurs at each of the four levels identified in Fig. 2. Whether or not the actual culture that results from this lifecycle process is functional or dysfunctional depends on a number of issues. In this illustration, we use the word 'formation' rather than 'formulation.'

One of the major ingredients in culture formation is

that of the internal integration process that leads to a set of shared, or not shared, assumptions. There are many issues and needs that affect this integration. Schein identifies six of these :

- (i) The need for communication, and a common language and set of concepts to enable this ;
- (ii) The need for group definition and identity, and for boundaries and criteria to determine group membership ;
- (iii) The need for determination of power distribution protocols ;
- (iv) The need for development of peer relationship protocols within the group ;
- (v) The need for determination of the approach used to define and allocate rewards for success and penalties for failure ; and
- (vi) The need to determine how to cope with risks that materialize, and unexplainable and uncontrollable events.

These represent a number of very philosophical and very pragmatic issues that, as a consequence, that have both moralistic and realistic overtones. They involve such fundamental issues as the definition of and what comprises truth, acceptable and unacceptable human activities and relationships, and how authority is used.

Six observables are identified by Schein as primary means to embed culture in an organization. Each of these measures, to some extent, the underlying assumptions, beliefs, and value system of the organizations leaders and represents strong drivers of an organization's culture. These observables are :

- (i) The critical factors that leaders measure and control ;
- (ii) The approaches taken in response to crises and critical incidents ;
- (iii) The observed criteria for resource allocation ;
- (iv) The activities of leaders as role models, teachers, and coaches ;
- (v) The observed criteria, used in practice, to allocate organizational rewards and status ;
- (vi) The observed criteria, used in practice, for recruitment of new organizational members and for outplacement of existing organizational members.

There are a number of supportive mechanisms that relate to organizational structure and processes, symbols and rituals, and formal statements of organizational purpose and philosophy. The formation of subcultures is an important aspect of organizational leadership. Subgroup and subculture formation is an

inherent likelihood that results from the differentiation process that invariably occurs as an organization expands and grows. Differentiation may be functional, geographical, divisional, hierarchical, or may result across products or markets. Subcultures are, in no sense, always harmful. They may be supportive or harmful to an organizations' mission depending upon how they are grown and how they mature.

In the concluding portions of this work, Schein devotes much effort to: organizational growth, maturity, decline, and rebirth; the role of information technology in organizations, and development of a learning culture. Information technology culture issues are important in this regard and Davenport is among those who have examined information technology cultures⁽³⁹⁾. This very much supports the notion that we should focus on how people use information first, and then focus on how machines should process information⁽⁴⁰⁾ in order to enable enhanced use and understanding of it by humans.

One of the major issues associated with organizational culture development is how to bring it about, in the form of change, successfully. This is especially critical for a new leader in an organization where the new leader does not have major experiential familiarity with the prevalent culture. It is particularly necessary in situations like this to obtain a relatively complete understanding of the existing culture before attempting to assess and alter it. A learning process is needed. While people may be capable of being taught, and they may learn, they cannot be learned. That is to say that one cannot impose learning on people. One reason why this is the case is that people need to be actively involved in the learning process if they are to learn. Schein suggest leadership by example as one major way to being this about. All of this is very supportive of the notion of developing a broadly shared culture that motivates everyone in the organization to search for appropriate solutions that enhance success in obtaining organizational goals. It supports the notions of treating everyone with respect and dignity and performing all tasks in a high quality conscious manner. A great many suggestions are provided in this work, and in two earlier works devoted to the role of external consultants in organizational process development and improvement⁽⁴¹⁾⁽⁴²⁾, that support organizational culture and leadership development efforts.

5. Organizational structures and networking

There are a number of ways in which organizational structures and organizational information needs

interact. This is especially important due to contemporary changes in organizational structure, which are influenced to a considerable extent by advances in information technology. Savage⁽⁴³⁾ illustrates this well in his identification of five recognitional stages, denoted as "days," in the life of many contemporary organizations. These findings may be described as follows.

(1) The organization is organized into a set of hierarchically related personnel and applications. These carry such titles as R & D, engineering, manufacturing, sales, service, and accounting. They report in a traditional line structures and the various functional units do not interact.

(2) In order to cope with the need for interaction, various application groups are set up. This creates a necessary linkage, or network, between one functional unit in the organization and the others that are needed for a particular application, such as product development or product marketing. Since the people in the various functional units cannot communicate well, or even at all, with one another as they speak different languages than those in other functional units, a "translator" or "expediter" is needed. Since there are many applications in a given organization, the network linkages become numerous, as does the need for expeditors and translators.

(3) The difficulties of working in parallel across functional units become apparent and ways are sought to cope with the resulting complexity. Someone suggests having customer expectations as the thematic drivers of considerations that relate to such non functional efforts as process, quality, market, and service.

(4) Concerns arise with respect to how the various crossfunctional teams are to be managed. Organizational vision is suggested as the monitor and controller of the cross-functional teams through the resultant strategic plans, organizational mission statements and objectives, and realistic management controls. Knowledge is recognized as a valuable resource in this regard in terms of various "knows." This knowledge is responsive to the same sort of questions used in benchmarking, except that it relates to a common knowledge base and capability for describing the various elements needed for each of the applications for which a cross-functional team is responsible. Thus, a knowledge base is needed in terms of Know Why, Know What, Know Which, Know Who, Know Where, Know When, and Know How. This represents the organizational knowledge base. It is what the various cross-functional teams bring to bear on various applications, such as product development. It

suggests a role for the original departments as "centers of excellence" or repositories for critical core capabilities, or "virtual resources," but not as actual working line units.

(5) In the last stage of development, the potential fragmentation of the organization due to the cross-functional teams is dealt with in terms of strategies for accountability, focus, and coordination. This leads to strategies for integrating the organization through human networking in such a way as to build a continual learning capability. These networks are not just informal networks of humans communicating with one another. This capacity is augmented by networks of information processing systems that enables interrelating various knowledge patterns for enhanced capability and competitiveness.

The strategies for human networking and enterprise integration result from the reality that the traditional resources for production - land, labor, and capital - are now augmented by an information and knowledge resource.

It is primarily this that has led for the major need to replace the traditional steep hierarchical structure found in most organizations by cross functional teams and human networking as to enable people empowerment and enterprise integration for enhanced responsiveness and competitiveness. The need is not to computerize steep hierarchies. In second generation management, steep hierarchies are introduced. Matrix management, of third generation management, accomplishes the change in organizational structure to enable horizontal communications through adding additional management complexity. In a sense, this is accomplished in fourth generation management without the additional management complexity through networking the organization. This involves major use of information technology and the need for integrating information technology products and services into organizational environments.

There has been much contemporary discussion of this augmentation of the traditional resource base with information and knowledge base. The Coming Post-Industrial Society work by Bell⁽⁴⁴⁾ was perhaps the first to indicate this shift some two decades ago. A more recent presentation is by Zuboff⁽⁴⁵⁾ who uses the term *Informate* to describe the effort of humans in simultaneously working at and on multiple levels of abstraction, each suited to a particular purpose. Such efforts will be prototypical and characteristic of the efforts of many in the emerging knowledge-based networked society.

There are a number of useful contemporary works that discuss such topics as the emergence of top management computer use⁽⁴⁶⁾, business design through information technology⁽⁴⁷⁾, and managing information technologies in the 1990s⁽⁴⁸⁾. More recent works are concerned with information technology and organizational transformation⁽⁴⁹⁾, information technology as an integrating force for such organizational efforts as marketing⁽⁵⁰⁾, strategic planning for information technology through information movement and management⁽⁵¹⁾, and how to increase organizational competitiveness and efficiency through use of information as a strategic tool⁽⁵²⁾. Peters has denoted the effort to integrate information technology and organizational consideration, and organizational needs for competitive positioning in a rapidly changing environment as *liberation management*⁽⁵³⁾.

In his work, Savage describes five generations of management organizations. The first of these is based on individual proprietorships and resulted from the use of two resources: land and labor. While organizations might take on a hierarchical appearance, they were not steep hierarchies. They did not need to be since the capital available to an individual proprietor would not allow this. In the latter portions of the industrial revolution, large amounts of capital became available. Without major knowledge resources, steep hierarchies naturally evolved as the large organizational model of choice. This represents the second generation of organizational structure. With recognition of the difficulties brought about by steep hierarchies, basically that of coordination across the various functions in the hierarchy, matrixed organizational structures resulted as third generation management organization structure. These matrixed structures brought about problems in that the notion of one person but more than one boss of that person creates many difficulties. This has led to general demise of matrix management structures.

Networking is suggested as a fourth generation management remedy for the dilemmas brought about by steep hierarchies and vertical management. In fourth generation management, horizontal and vertical communication linkages are established for what was initially the second generation model of management structural organization. This is not really enterprise integration in that the organization is not truly integrated, except in a narrow technological sense by the wires and software that one person uses in interfacing with another. It is really just computerizing a steep hierarchy, with perhaps 10 to 20 layers of management. Savage identifies

six issues that generally emerge from fourth generation management :

- (i) Ownership of information issues, as information becomes "turf" in a steep functional hierarchy ;
- (ii) Managed and massaged information system issues, as various functional units presents selective information that best supports their unit ;
- (iii) Hidden assumptions imbedded in various software representations of levels of abstractions and associated information presentations ;
- (iv) Inconsistent terms and definitions across different applications, which are due to lack of organizational standardization of information architectures and dictionaries ;
- (v) Accountability and social value of information; and
- (vi) Organizational information politics.

Some of these are not inherent issues in information technology and networking, but are aided and abetted by retention of the steep hierarchy form of management. It would appear that these are very related to and influenced by organizational cultures and information cultures. Second, third, and fourth generation management each involve steep hierarchies. Third generation management attempts to improve on horizontal communication needs through a matrix management structure, but this superimposes additional management layers and brings about the difficulty of one worker reporting to more than one supervisor. There are communication difficulties as well. Fourth generation management attempts the needed horizontal communication through technology but does not fully ameliorate the other difficulties we have just cited.

Savage presents a number of illustrations in an attempt to show that the computerization of steep hierarchies, or fourth generation management, really will not work. He presents five needs, in the terms of a set of interrelated conceptual principles, that form the nexus of early fifth generation management and which will enable the desired transformation.

(a) *Peer-to-peer networking* is a major need. This involves three major ingredients : technologies, information, and people. Peer-to-peer networking enables communication from any individual in the organization to any other individual without the necessity of having to go through the conventional steep hierarchical structure. It allows people to work together in a cross-functional manner. Far from eliminating hierarchies, this results in a redefinition of the role and function of the hierarchy

and a resulting hierarchy that is much flatter than before networking. While there are major hardware and software difficulties in bringing this about, the human and organizational issues are larger and more complex.

(b) *Work as dialogue* is another important need. This involves listening, visioning, remembering, and using knowledge relative to both process and product.

(c) The *human time and timing* need is concerned with developing an understanding of past, present, and future patterns such that it becomes possible to see and anticipate future patterns of the basis of experiences and knowledge.

(d) An *Integrative process* across people, technologies, and the organization allow for continuous change and teamwork in the organization, as contrasted with the pattern of unfreezing, change, and refreezing⁽⁵⁴⁾, typically in a reactive fashion, that does not support continued improvement over time except at the discrete time instances where refreezing and change occur.

(e) *Virtual task-focusing teams* is the final major need and results only from satisfaction of the first four needs.

On the basis of these principles, he suggests ten pragmatic organizational considerations for enabling fifth generation management.

(1) Develop a technical networking infrastructure that is flexible and adaptable to organizational needs and continual change.

(2) Develop a data integration strategy.

(3) Develop functional centers of excellence.

(4) Develop and expand the organizational knowledge base.

(5) Develop organizational learning, unlearning, and relearning capabilities that are continuously updated and rejuvenated.

(6) Develop visioning capacities so that the context for judgments and decisions is visible to all through knowledge of strategic plans and organizational objectives, mission statements and values.

(7) Develop behavior norms, a sense of values, a reward structure, and measurements that support task-focusing teams.

(8) Develop the organizational ability to identify, support, and manage multiple functional-task teams.

(9) Develop the organizational capacity and capability to support the teamwork of teams.

(10) Develop virtual task-focusing teams that are formed of suppliers, customers, and appropriate people from within the organization.

The first two are primarily technology based needs,

although there is much need for human interaction with the technologies to be implemented. The last needs have very much to do with people. Those in the middle represent organizational needs. There is not sharp cleavage between technology, organization, and people needs; as major ingredients for reengineering.

Notably lacking in this work is a very clear explication of the structure of a fifth generation organization. It is indicated that the horizontally functional units in the typical organization are wrapped around into a circle, and that there are linkages to customers and suppliers, and organizational cognitive connections to knowledge and vision. But, aside from this, no explicit structure is shown. Perhaps it is simply too early in the development of fifth generation management strategies, purposes, and functions to be concerned with specific organizational architectures. Perhaps it is simply best to let an individual organization adapt to a structure that fits best in with its evolution to the fifth generation.

Notions of horizontal management as an approach to reengineering, or perhaps more appropriately as the result of reengineering have been suggested by many. We have attempted here to provide a salient overview of one of the major works on horizontal management. Essentially all of this suggests an approach towards creation of a horizontal organization that involves the sort of definition, development, and deployment phased efforts illustrated in Fig. 3. As we have discussed here, and throughout much of our discussion in this chapter

and the last two, the major precepts in implementing this and other approaches for total quality management and strategic reengineering involve the following 12 efforts.

- (1) Make customer satisfaction the major driver of the organization, and the major driver of organizational performance.
- (2) Maximize contact and interaction with customers and suppliers.
- (3) Educate, train, and informate all organizational personnel with respect to knowledge about the organization's mission relevant areas as well as with respect to general problem formulation, analysis, and interpretation abilities.
- (4) Organize about cross-functional, and generally multidisciplinary teams that are self-managing and accountable for their performance responsibilities.
- (5) Use cross-functional teams to manage virtually everything.
- (6) Reward team performance.
- (7) Define the organization's missions and critical objectives.
- (8) Identify the strategic processes, and those which are non essential or redundant as candidates for abolition.
- (9) Organize around processes and not functions or departments.
- (10) Assign a process owner to each process.
- (11) Flatten the hierarchy to reduce unnecessary

Fig. 3. Lifecycle phases in implementation of horizontal management in an organization.

layers of management and administration and to increase worker empowerment.

(12) Develop an interactive and proactive measurement system to assist in guiding the development and deployment of the strategy as a results oriented set of activities.

It is important to note that maximization of short term, or long term for that matter, profits is not one of the fundamental objectives or activities. Profit is really, and should be regarded as, an objectives measure. If this is not done, ultimately the organization suffers, through the short range perspective that typically results.

There are many challenges associated with implementation of a horizontal management outlook. Among these are the culture and leadership issues we addressed earlier. These relate to many of the concerns associated with bringing about total quality management⁽⁵⁵⁾, such as the implementation of work teams⁽⁵⁶⁾⁽⁵⁷⁾, which will generally be self managing, and implemented for cross-functional purposes to meet organizational performance challenges for competitive advantage through people⁽⁵⁸⁾.

6. Organizational transformation through information technology

We view systems engineering efforts as being concerned with product, process, and systems management⁽²⁾, as suggested by Fig. 4. We have also illustrated how reengineering efforts can be conceptualized at each of these three levels⁽⁵⁹⁾. We can envision a maturity model for systems engineering as being comprised of efforts at

there three levels. As an organizations' capability and maturity improves, it becomes able to deal with issues at the levels of process and systems management, whereas

Fig. 4. A systems engineering perspective on some of the many ingredients influencing product and system development.

Fig. 5. Various hypothetical levels in systems engineering maturity.

Fig. 6. Representation of two levels for product or system reengineering, and associated characteristics.

lower maturity organizations are able to deal with issues primarily or exclusively at the level of product. Fig. 5 is a conceptual illustration of such a maturity model.

In an insightful recent article, Venkatraman⁽⁶⁰⁾ identifies five levels for organizational transformation through information technology. We can expand on this slightly through adoption of three levels for

reengineering we have described here and obtain the representation shown in Figs 6~8. These figures show our representation of five levels, two for product or system reengineering, one for process reengineering, and two for reengineering at the level of systems management. Organizational reengineering is generally revolutionary and radical, whereas product reengineering is usually evolutionary and incremental. Process reengineering may be at either of these extremes. Figs 6~8 may be viewed as expansions of Fig. 5. We view these not only as levels for reengineering through information technology, but also as maturity levels for systems engineering efforts. These are analogous to comparable maturity levels identified in the quality movement⁽²⁾ and capability levels for improving the software process⁽⁶¹⁾.

In his work, Venkatraman notes technological and organizational enablers and inhibitors that will affect desired transformations at both evolutionary and revolutionary levels of transformation. The technological enablers include increasingly favorable cost-effectiveness trends for various information technologies and enhanced connectivity possibilities. Technological inhibitors include the lack of currently established standards that are universally accepted and the rapid obsolescence of current technologies. Organizational enablers include managerial awareness of the need for change and existing leadership. Organizational inhibitors include financial limitations and managerial resistance to change. While both product reengineering and organizational reengineering desires will ultimately

Fig. 7. Representation of process reengineering, and associated characteristics.

Fig. 8. Representation of two levels for reengineering at the level of systems management, and associated characteristics.

Top down directed changes, from level V to lower levels is often directed at capability and effectiveness enhancement. Efforts directed from Level I up are generally concerned with efficiency enhancement. It is generally at the level of improved processes that enhancement in efficiency and effectiveness may both be realized.

It is generally the case that organizations should develop strategy first, then determine appropriate processes, and then choose appropriate information technology and other products that are most appropriate. There are exceptions, however, and an interesting case study is described in Ref. (62) of an organization, with a high organizational learning capacity and a mature approach to risk management, in which incremental adoption of information technology, was a driver of strategic change. So, change can be initiated at any of these levels. Systems management deals with appropriate changes at all of these three levels and with efficiency and effectiveness, and also with the explicability and equity issues necessary to bring this about and to insure a better tomorrow.

7. Summary

We have attempted to describe some of the major needs for information technology and information systems in enhancing organizational effectiveness. To do this, we described several different perspectives on organizations and how organizational information contributes to, or detracts from, organizational learning. Important in this regard is the critical use of information technology and organizational information systems to enhance the ability of organizations to move from reactive approaches to management and quality to interactive and proactive approaches. Next, we examined organizational cultures and posed the claim that information technology supports the development of a learning culture. This led us to examine, briefly, contemporary developments in organizational networks and the critical role of information technology and information systems in supporting human for enhanced organizational productivity. This led us to consider reengineering efforts for enhanced organizational productivity. As in

Fig. 9. The role of cost-effectiveness in systems engineering and reengineering at the levels of product, process, and systems management.

Fig. 4, information systems engineering efforts may be realized at the levels of product or systems, processes, or systems management. A major need in determining the most worthy mix of efforts at these three levels is determination is the most appropriate requirements for effort at each level. There are a number of ingredients that must be considered and some of them are indicated in **Fig. 9** which, together with Fig. 4, highlights the three effort levels needed to evolve information systems engineering strategies for organizational effectiveness.

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