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ABSTRACT

Although educational reformers frequently use the words "system," "systemic change," and "systemic approach," many lack a fundamental understanding of the systems concept. This paper describes the application of systems theory to the problems of educational reform and educational assessment. It introduces basic concepts and principles and describes a generic model for the application of systems theory to educational reform. Educational reformers should view systems as complex, pluralistic, open, and teleologic. The model must have the following features: (1) an open view of education; (2) recognition of the system's vision, mission, and goals; (3) alignment of the vision, mission, and goals of individuals with those of the system; (4) well-defined methods for promoting communication across barriers and breaking down existing communication barriers; (5) feedback mechanisms to maintain dynamic homeostasis; and (6) action-producing mechanisms to analyze environmental feedback and design the most effective action. Six figures are included. (LMI)

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*When placed in the same system, people, however different, tend to produce similar results.
(Senge, P. 1990, p42.)*

INTRODUCTION

The words "system", "systemic change", "systems approach" and other similar terms are heard with increasing frequency in educational circles, especially among advocates of "systemic reform". It appears, however, that only a small portion of those who use these terms have more than a rudimentary understanding of the concept of a system and the valuable theory of systems that has evolved to explain what systems are and how they function. This view is shared by Betts(1992) who says

"Unfortunately the word *system* has been popularized without a fundamental understanding of its implications, to the point where everything is a system but nothing really is treated like one. Many people say they are using a systems approach, but almost no one really is." (p.38)

Many educational professionals remember the 1960s and 1970s and may therefore recall with some distaste the adaptation of some systems theory concepts to education. Examples include management by objectives(MBO), program planning and budgeting systems(PPBS), programmed instruction and other such applications that made procedural demands on users and yielded little in terms of measurable improvements either managerially or instructionally. Unfortunately, those were in many instances, maladaptations of processes and techniques from the world of scientific management and systems engineering rather than adaptations of a systems theory approach. The result of those efforts created an association in the minds of many educators of the word "system" with complex, detail laden procedures and forms for use in program budgeting, management by objectives, and other processes that always seemed to be creating paperwork burdens and somehow missed the big picture of what education was about. Now, nearly thirty years later, education is rediscovering the concept of "system". The first time around we got lost in the details and the trappings without capturing the philosophy and richness of thought that systems theory had to offer. Had we not done so we might find education at a new, higher plane than it is today. This time around we hope to get it right.

This paper focuses on the application of systems theory to the problems of educational reform and to educational assessment. It has two major purposes or objectives:

- to introduce the reader to some basic systems concepts and principles of systems theory as they apply to education, and
- to describe a generic model for the application of systems theory to educational reform.

BASIC SYSTEMS CONCEPTS AND PRINCIPLES AS THEY APPLY TO EDUCATION

The term "system" has many legitimate and useful applications in describing and analyzing the way education is organized and conducted. We may in fact, think of many education systems and subsystems that interact in myriad ways to define what we think of as the American education system. There are also state systems, county systems, city-wide systems and local systems. In each case a legitimate application of the construct "system". This section explores the concept of a system and applies systems theory to education by drawing from the works of both systems and educational theorists.

Among the more influential advocates of the need for a systems view of education is Seymour Sarason who, in his book, *The Predictable Failure of Educational Reform (1991)*, advocated that a total system view of education was essential if meaningful reform was ever to occur. In Sarason's words

"System is a concept we create to enable us to indicate that in order to understand a part we have to study it in relation to other parts. It would be more correct to say that when we use the concept *system* it refers to the existence of parts, that those parts stand in diverse relationships to each other, and that between and among those parts are boundaries (another abstraction) of various strength and permeability. Between system and surround are also boundaries, and trying to change any part of the system requires knowledge and understanding of how parts are inter-related. At the very least, taking the concept of system seriously is a control against overly simple-cause-and-effect explanations and interventions based on tunnel vision." (p.15.)

This failure to recognize and understand the relationships among the inter-related parts of a system is, in Sarason's view the major reason that repeated attempts at educational reform in the United States have failed, and will continue to fail, if not properly addressed.

Sarason has appropriated the systems view from the social sciences, and in particular from sociology and social psychology, where the study of complex human social systems has been taking place for more than a hundred years.

Two basic types of systems

Systems theorists define two basic types of systems, "open" and "closed". Prior to the advent of open systems thinking systems models were of a closed nature. They relied on laws of Newtonian physics and assumed such conditions as might exist in a laboratory environment where a chemical reaction could be controlled in a beaker, isolated from extraneous input that might interfere with the desired outcome. These models shared a common feature in that the system did not interact with its environment. It was instead thought of as being enclosed within permanent boundaries, isolated from interaction with other systems. Some writers have attributed the disintegration of the Soviet Union to its more closed than open nature, which prevented it from importing the intellectual energy to sustain itself (Banathy, 1992.)

Open systems

An educational system is a social organization and all social organizations are open systems as opposed to closed systems (Katz, D. and Kahn, R.L., 1966.) Therefore, I will focus my attention on open systems exclusively throughout this paper.

School systems are "moderately open" (Betts, 1992, Banatny, 1991). According to Katz and Kahn (1966) open systems share the following nine common characteristics.

- importation of energy
- the throughput
- the output
- systems as cycles of events
- negative entropy
- information input, negative feedback and the coding process
- the steady state and dynamic homeostasis
- differentiation
- equifinality.

In addition to these nine characteristics, Betts (1992) has added

- synergy
- hierarchy, and
- purposiveness or teleology.

Each of these terms is discussed briefly below, with an illustration of how it applies to education.

Importation of energy. A primary distinction between open and closed systems is the exchange of energy across boundaries. Living organisms are open systems, taking in fuel, oxygen, and other requisites from their environment and returning waste products and useful elements such as nitrogen and carbon dioxide. Most large scale organizations are dependent on the social effects of their output for energy renewal (Katz and Kahn, 1966, p.90.) In other words, the system's output affects the system's environment in some way that stimulates a return of energy from the environment to the system. When this exchange is mutually beneficial, *symbiosis* occurs, an interdependent relationship between system and surround.

As a social system, an education system is open to energetic input from its environment through a variety of mechanisms. Policy direction is provided by its elected board of education, representing the will of constituents who may be outside the system. Local PTA/PTO, school site councils, advisory accountability committees and various other representative groups influence the way in which schools and school systems conduct the education process. Funding is in many instances, subject to an electoral process and so on. Educational reform ideas influence the operation of the system after having found their way into the system through varied sources, e.g., literature, pre-service and in-service training, state and federal legislative mandates and even public input. All of these sources of energy serve to both sustain and transform an education system.

The throughput. The throughput is the transformation of imported energy to output by means of the processes and functions of the organism or organization (Katz and Kahn, 1966.) The human body converts starch and sugar to heat and action. The factory transforms raw materials into products and the school transforms a multitude of inputs such as educational theory, monetary resources, characteristics of incoming pupils, community attitudes, values, and instructional resources into applied knowledge and skills manifested in the students who pass through the system.

The output. Open systems export some product into the environment (Katz, D. and Kahn, R. L., 1966, p.93.) In the case of a biological organism, it may be nitrogen and carbon dioxide. In the factory example it is a consumer or capital good such as an automobile or industrial robot. In the case of a school it is a citizen who can solve problems, find and use information effectively, and function

successfully in society. The mission statement of the school or the school district will express the value ideal associated with the output.

Systems as cycles of events. The exchange of energy between a system and its environment is cyclical in its nature. The product returned to the environment becomes the source of energy for repetition of the cycle of activity. In biology the nitrogen and carbon dioxide help sustain and stimulate the production of plants which provide sources of energy either directly or indirectly for the sustenance of the organism which may consume them or consume other organisms which consume them. The computer manufacturer's product generates the needed revenue to purchase more components and provide a return to investors. The output of a school however, contributes to a complex set of interactions within society which influence the flow of energy back into the system.

For example, a student may become a politician who influences tax legislation that directly affects school funding. Or she may become a scientist, contributing to a new scientific theory or discovery that becomes incorporated into the curriculum. The student will, most likely, become a taxpaying citizen who eventually has children of her own in the system, and may even join the PTA and become an advocate for school reform, expressing herself through letters to board members and meetings with the teachers and principals who influence her children.

Over time this repetitive cycle may result in changes within the school system. Such changes can be organizational, philosophical, curricular or in the instructional process. These changes occur naturally in response to the influence of environmental, social and economic factors, which themselves are transformations of inputs in the larger system of society. By the same token, subsystems will contain their own cycles of activity or loops within the larger system, based on the exchange of energy within the system's internal environment.

Entropy and Negative entropy. Entropy is a systems theory concept whereby all forms of organization, biological, social or physical move toward cessation of activity and ultimate death. A classic example within physics is found in the second principle of the law of thermodynamics which states that a system tends toward a state of equilibrium in which its elements become arranged in a random, disordered fashion. Heating a bar of iron on one side with a blowtorch will result in a speeding up of the heat exposed molecules on that side. Eventually some of the energy from the heated up molecules will dissipate into the surrounding environment and will also increase the activity of neighboring molecules until all molecules within the bar are at an equal temperature and rate of movement. Further dissipation of heat energy will heat the surrounding environment until the bar and its environment are the same temperature. Entropy continues until the physical system reaches the state of the most probable distribution of its elements (Katz and Kahn, 1968.)

Another way of thinking about entropy is that if a non-living system is isolated or placed in a uniform environment, all motion usually comes to a standstill, eventually, as a result of various sources of friction or resistance. Differences of electric or chemical potential are equalized, and differences of temperature are equalized, resulting in a permanent state of cessation of activity known as thermodynamical equilibrium or maximum entropy (Schrodinger, 1945.)

Negative entropy is the reversal of the entropic process so as to perpetuate the differentiation of a system, rather than to decrease it to a moribund state of torpor. Because they are open systems, importing negative entropy, social systems, differ from physical systems in that their structures tend to become more elaborated rather than static. This is evident in school systems in the elaboration of the curriculum, differentiation of roles of the administrators, counselors, psychologists, social workers, nurses, teachers with diverse endorsements and certifications, and the increasing complexity of regulations and legal requirements that school systems face today that didn't exist in earlier times.

Examples of increasing the negative entropy of a school system include increasing school funding through legislative action or a mill levy, introduction of a new instructional methodology or assessment system and creation of new partnerships with business and industry. Each of these actions would result in new structures within the system, creating new functions and activities, thereby counter-acting the effects of entropy on the system.

Information input, negative feedback, and the coding process. The inputs into a system may be of an informational nature as well as energetic. Informational inputs provide important signals about changes in the environment which have implications for the way the system operates. Feedback is one type of informational input. Feedback may be either positive or negative. Positive feedback from the environment signals the system to continue on its current course. It may be selective, focusing on a particular program, department or aspect of the curriculum or it may be more diffuse and general. Information feedback to the system will vary in terms of specificity and quantity. More specific information is generally more useful to the system in formulating plans or making specific choices among alternatives, whereas general information is more useful for policy guidance (Hansen, 1992.) Systems can react only to those inputs to which they are attuned and the process of transforming the input signal into useful information is known as coding (Katz & Kahn, 1966.)

Negative feedback signals the system that something is wrong. This type of information which suggests an alteration to the system's current course is central to system theory. A thermostat, for example, controls the temperature in a room by sensing when the temperature has deviated from the acceptable range and sending a signal to the heating or cooling unit to either increase the output of heated or cooled air.

School systems need thermostat mechanisms to monitor the social, political and economic climate in which they operate. Examples of such mechanisms might include community needs/satisfaction surveys, focus group or town hall meetings, client hot lines, citizen advisory groups and program evaluations. These mechanisms become sensors for detecting conditions that will produce negative feedback. They can collect, codify and process that negative feedback, thereby causing corrective actions to occur within the system. Without such feedback mechanisms, school systems can become non-responsive, isolated entities, which are more closed than open and therefore more subject to the effects of entropy.

System theorists (Katz & Kahn, 1966; Miller, 1955) postulate that if there is no such corrective device a system will consume too much energetic input, or consume too much energy and will eventually cease to exist as a system. Obviously the implications of this for a public school system are complicated by legal requirements that such a public system exist. Nevertheless, it is consistent with systems theory that a school system which fails to respond to signals for change from its environment will ultimately suffer the dire consequences of reduced funding, legal sanctions, or a loss of enrollment, which could, if not stemmed, lead to failure of the system. Therefore, a healthy school system should actively develop and maintain its feedback mechanisms and seek to maximize the effective use of the feedback thus obtained. It must also have mechanisms in place for utilizing such feedback in a process of continuous improvement. It is not enough to merely capture and contain the feedback, it must be used to make corrective changes in both the substance and processes of curriculum, instruction and administration. Therefore a mechanism or sub-system is needed for converting feedback to corrective actions through program or organizational development, revision, or redesign.

The steady state and dynamic homeostasis. A healthy system is constantly searching for a dynamic balance through self regulating mechanisms. Relationships among elements, subsystems and suprasystems are constantly changing in search of equilibrium while avoiding entropy (Betts, 1992, p. 39.) Dynamic homeostasis is the process by which, once established, a system will act to preserve its essential character. This is accomplished through constant exchange of inputs and outputs with the

external environment where the inputs are either energetic or informational and the outputs are the products of the system. In an animal or human, homeostasis is maintained through the ingestion of essential nutrients, the regulation of body temperature and the release of bodily waste. The animal or person may grow, and through the process of cell regeneration even become a different physical being, but the essential character of the being does not change. In a social system a similar process occurs. The system may change in response to energetic or informational inputs, but its essential nature will remain the same. That is to say that a school system's purpose and basic operational characteristics will likely remain unchanged, even though it may be affected by staff turnover, funding fluctuations, reform movements and other political, social and economic events. To insure survival, systems will act to acquire some margin of safety beyond that required for existence (Katz & Kahn, 1966, p.99.) The human body for example, may store fat; a corporation will establish reserves. Social systems will tend to incorporate within their own boundaries those external resources essential for survival. The equilibrium established by the system will be a long-term condition, based on its purpose. Homeostasis will be based on preserving the essential character of the system, not on maintaining a specific form with all specific functions continuing intact.

The widely held perception that public education is a conservative institution which resists change at all costs, may stem from fears based on mis-perceptions by professional educators, that changes in the system will disrupt its equilibrium. This view confuses long-term equilibrium with *staticism*, or a permanent condition of non-change. Understanding equilibrium as a long-term dynamic process may help educators to reduce their fear of change as a threat to systemic equilibrium.

School systems are subject to specific restraining forces that affect the ways in which they can change and still maintain dynamic homeostasis. For example, the willingness of voters to support property tax levies is one such constraint. Social constraints in terms of the acceptability of certain curricular variations, such as sex education or AIDS education are a variable in the school community. The former Chancellor of the New York City Public Schools, Joseph Fernandez found severe community resistance to his program to distribute condoms to students to prevent AIDS. This public resistance ultimately led to his dismissal. The recent upsurge of interest in and activism toward public education by conservative religious groups, concerned with the moral decay of society, is another example of such a constraint.

The vital role of public education in a free society creates conditions which spawn many self-interest groups that monitor the education system and keep it operating within certain acceptable boundaries defined by mainstream values and reflective of the social, economic and political environment. Dynamic homeostasis for a school system is established within those boundaries over the longer term.

Differentiation. Open systems progress from simpler to more complex structure as they evolve and grow. This is true of biological as well as social systems. In social systems, and in particular - school systems, increased differentiation is constrained by environmental variables such as those discussed above. Limits are determined by societal values, public opinion, economic factors and other intrinsic factors. Currently we are experiencing a societal trend toward simplified organizational structures with less middle management. The Total Quality Management (TQM) approach of W. Edwards Deming has had a profound, if belated effect on American management theory and we are beginning to experience a cross-over of this influence from industry to the public schools. This is not the first time such a cross-over has occurred. Much of the scientific approach to education of the 1960s and 70s crossed over from the teachings of Frederick Taylor, some thirty five years earlier.¹ The effects of this more

¹ For a discussion of the influence of scientific management on educational accountability and reform see Hansen, J.B. Is Mandated Accountability as a Tool for Educational Reform an Oxymoron? Measurement and Evaluation in Counseling and Development, April, 1993, vol.26.

recent cross-over include site-based management accompanied by reductions in central administration staff. Thus we see a "dedifferentiation" such as that described by Gouldner(1959) in which a system reorganizes at a lower level of complexity in response to a disturbing stimulus. A system's ability to dedifferentiate is dependent on the degree of functional autonomy of its parts and the tension between the parts and the system. Dedifferentiation may lead to new growth and further differentiation as the original sources of tension are relieved. Therefore we may expect to see new and different structures in the education system. And we may also see a thriving and growing system of education based on these new structures. Some may even describe this phenomenon as educational renewal.

Equifinality. The principle of equifinality states that "...In any closed system the final state is unequivocally determined by the initial conditions: for example the motion in a planetary system where the positions of the planets at a time t are unequivocally determined by their position at time t_0 . Or in a chemical equilibrium the final concentrations of the reactants naturally depend on the initial concentrations" (Bertalanffy, 1955.) The principle of equifinality as applied to open systems, suggests that *a system can reach the same final state from differing initial conditions and by a variety of paths.*

The application of the principle of equifinality to educational systems would suggest that a system could move toward a desired end state regardless of the condition or status it manifests at a given point in time. This principle implies that a degree of plasticity exists in school systems which should be taken into account by those who fear that structural changes to the organization will necessarily have detrimental results.

Synergy. Another characteristic of systems is that they exhibit *synergy*. That is to say that a system is more than just the sum of its parts because the relationships among the elements of the system add value to the whole. (Betts, loc.cit.) According to Katz and Kahn (1966) system theory is basically concerned with problems of relationships, structure and interdependence among elements rather than with constant attributes of objects. (p. 90.) While synergy may be difficult to observe directly, in an education system, it nevertheless occurs with some frequency.

Hierarchy. The hierarchy of a system is determined by the number of levels that exist within it. Each successively higher level encompasses all processes at each lower level and is increasingly complex as the number of elements and the relationships among elements or subsystems increases. The energy required to maintain the system increases at an even greater rate than does the complexity. Arbitrary or man-made hierarchies require even more energy to maintain than natural ones such as birth order within a family (Betts, 1992, p.39.)

Purposiveness in systems. A system must have some purpose for which it exists and seeks to sustain itself. For an ecosystem the purpose may be the survival and continuation of the varied species of living organisms it supports. For an organization or system such as education the purpose may be less clear. It is currently in vogue for organizations to go to great lengths to establish vision, mission and goals to clarify their purpose and communicate it to their employees and clients. When the goals of an organization are not the same those of as its members, dissonance results. This dissonance releases unfocused or diffuse energy which may have a counter-active effect on the common goal focused energy, thus creating resistance or friction which impedes the accomplishment of system goals and objectives. It is important to recognize however, that the input, output and functions of an organization may define its purposes more accurately than the stated intent of its leaders (Katz and Kahn, 1966.) Therefore it is crucial for the long term health of the system that each member (employee and student) of the system understands not only the purpose, but also the relationship between that purpose and his or her own role in the system.

Banathy(1991) distinguishes between *unitary* and *pluralistic* systems. *Unitary* systems have a single clear goal whereas *pluralistic* systems have multiple goals, some of which may conflict with others.

School systems operate under numerous legal mandates which themselves create a variety of purposes or goals, some of which may be in conflict with others, thereby requiring greater energy to maintain the system and the relationships within it (Betts, 1992.) School systems are therefore pluralistic.

THE MODERN SCHOOL SYSTEM

Alternative Systems Views of a School System

Various educational theorists and scholars have developed systems theoretic views of education. In this section a brief overview of three different systems perspectives on education is provided. First is the hierarchical model of Patrick Dolan, followed by the systems design approach of Bela Banathy, then the TQM systems view of Jerry Herman.

Hierarchical model. Patrick Dolan (1991) attributes much of the alleged dysfunctionality of the modern school system to the fact that it is based on a hierarchical model that originated in ancient times and has since become obsolete. This model worked well through the era of the Roman empire, providing the framework for military governance. It is also, according to Dolan, the basic organizational model of the (Catholic) church and provided the mold from which all subsequent military, governmental and industrial organizations were formed. Dolan suggests that this model is no longer functional because it is designed for one way communication only, from the leader to all those below. To Dolan, the restructuring of education must begin with the communication system, by making changes in communications at the boundaries of the subsystems to promote a more open, two way exchange within the system as well as between the system and its environment. In other words, moving the education system model further toward becoming an open system.

(Insert Figure 1 . The hierarchical organization of a school district)

Figure 1 shows how a typical school district is organized. This pyramidal structure is characteristic of military forces, churches, monarchies and, until recently, most post-industrial era social and business enterprises. Such systems are relatively closed, rather than open, and designed more for information flow from the top down than from the bottom up. They contain many barriers to communication which occur at the boundaries of the subsystems (Dolan, 1991.) These barriers tend to isolate the subsystems from one another thereby inhibiting, rather than promoting interaction, restricting the flow of vital energy within the system, and between the system and its environment. In a pluralistic system such as a school district, this can result in a self perpetuating cycle of isolation and alienation from the system's goals, because the sub-systems and their components are focused on their own goals. This happens because the one way communication grid does not encourage the flow of information from lower levels of the hierarchy which the system needs to make internal adjustments so that it can stay on its plotted course.

At least two strategies are necessary in order to overcome the problems of the hierarchical system model. One is to reduce the number of layers in the hierarchy, thereby promoting more direct interaction between the top, policy level decision makers and those at the operational level, i.e. the teachers. A second necessary strategy is to create means of removing or weakening the barriers between sub-systems that impede the information flow within the system. This can be facilitated by establishing communication teams comprised of representatives from adjacent sub-systems to bridge the barriers by establishing and sustaining a continuous flow of information across sub-system boundaries. A specific example of this in a larger district would be a cross-divisional or cross-departmental coordinating council. In the Colorado Springs Public Schools we have established such a council - Curriculum, Instruction and Assessment Coordinating Council (CIACC), made up of representatives from the Division of Instruction and the Division of Data and Technology Systems. The

Division of Instruction has responsibility for curriculum development, instructional supervision and school management. The Division of Data and Technology Systems has responsibility for student data systems, Management Information Systems, planning, evaluation and measurement. The CIACC meets monthly during the school year to discuss and make decisions about issues of common interest to the two divisions, such as developing new assessment techniques, meeting

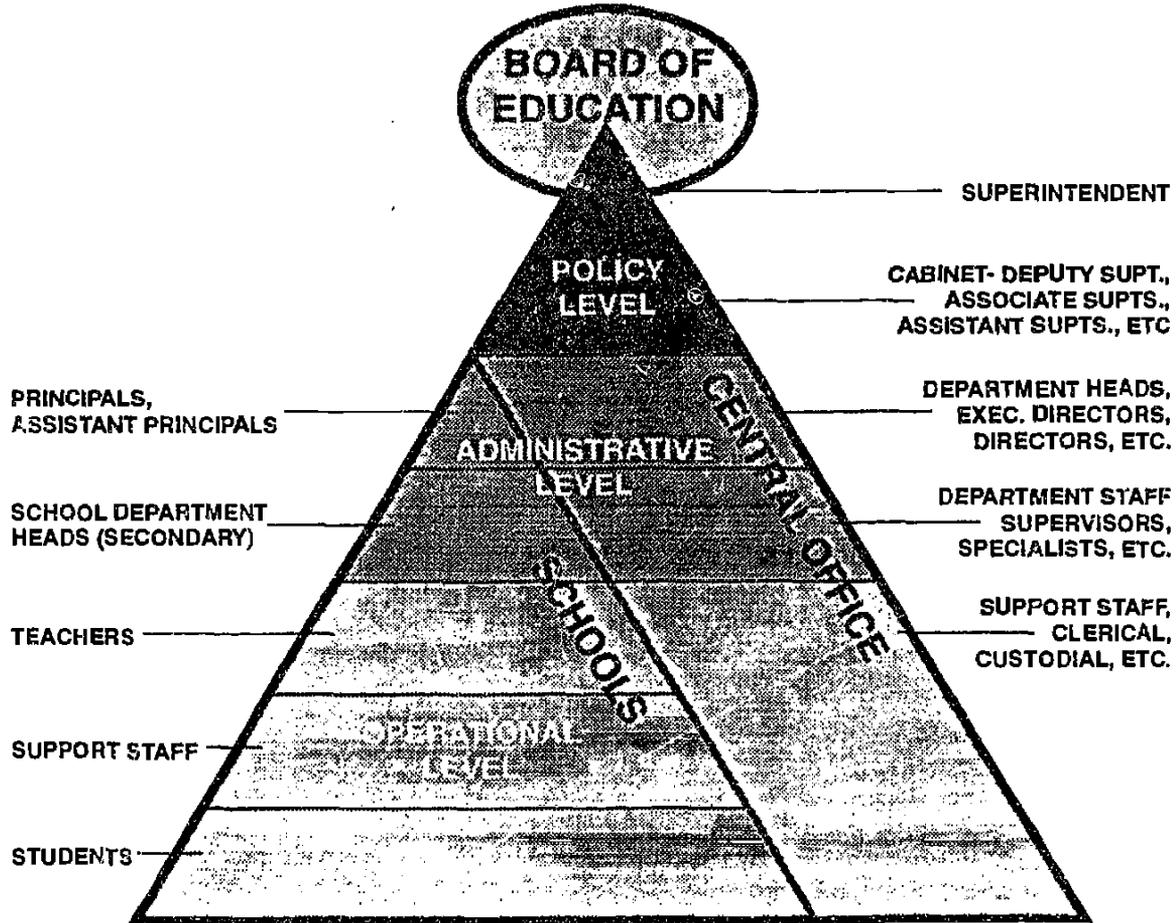


Figure 1. Hierarchical Organization of a School District

state accountability requirements, review of instruction and assessment policies, setting up and monitoring pilot programs in assessment and so on. The existence of the CIACC helps to ensure that there is a continuous flow of information back and forth across the boundaries between these two organizational units, each of which has a separate mission, in support of the district mission, but which share many common interests. Without such a structure as the CIACC the potential for misunderstanding and conflict of interests would increase considerably.

A design based approach to systemic reform. Banathy, (1991) asserts that there is an ever widening gap between education, which is relatively slow to respond to the need for change, and the rest of our rapidly changing society. He also says that the current model based on the industrial society is outmoded and has lost its viability and usefulness. Banathy advocates that we must go beyond reform to transform our outdated school system model; that making adjustments to the current model won't work, because the model is based on an outmoded mindset of *determinism*, which fails to deal with interactions among all the constituent parts of the system. According to Banathy our efforts at educational reform in the past have failed because 1.) they were piecemeal and incremental, and 2.) they failed to integrate solution ideas into a complex interactive whole or system, and 3.) they remained within the boundaries of our current system. Banathy also believes that focusing on the system as it exists instead of designing a new system will not work. Banathy calls for the design of a new education system based on a *vision* of how things should be which results in an *image* of a new system that addresses societal needs and is focused around current and anticipated future issues.

Banathy's approach to systemic change may be the most extreme and comprehensive to have emerged thus far. It fails however, to acknowledge the natural and historical fact that most change does occur incrementally and that evolution accounts for more change than revolution does. It would also appear that Banathy does not accept the principle of *equifinality* as being applicable to education systems or he would recognize its implications for making incremental changes in order to reach the desired end state.

Total Quality Management as a system in education. TQM also provides a systems approach to education, as expressed by Herman(1992.)

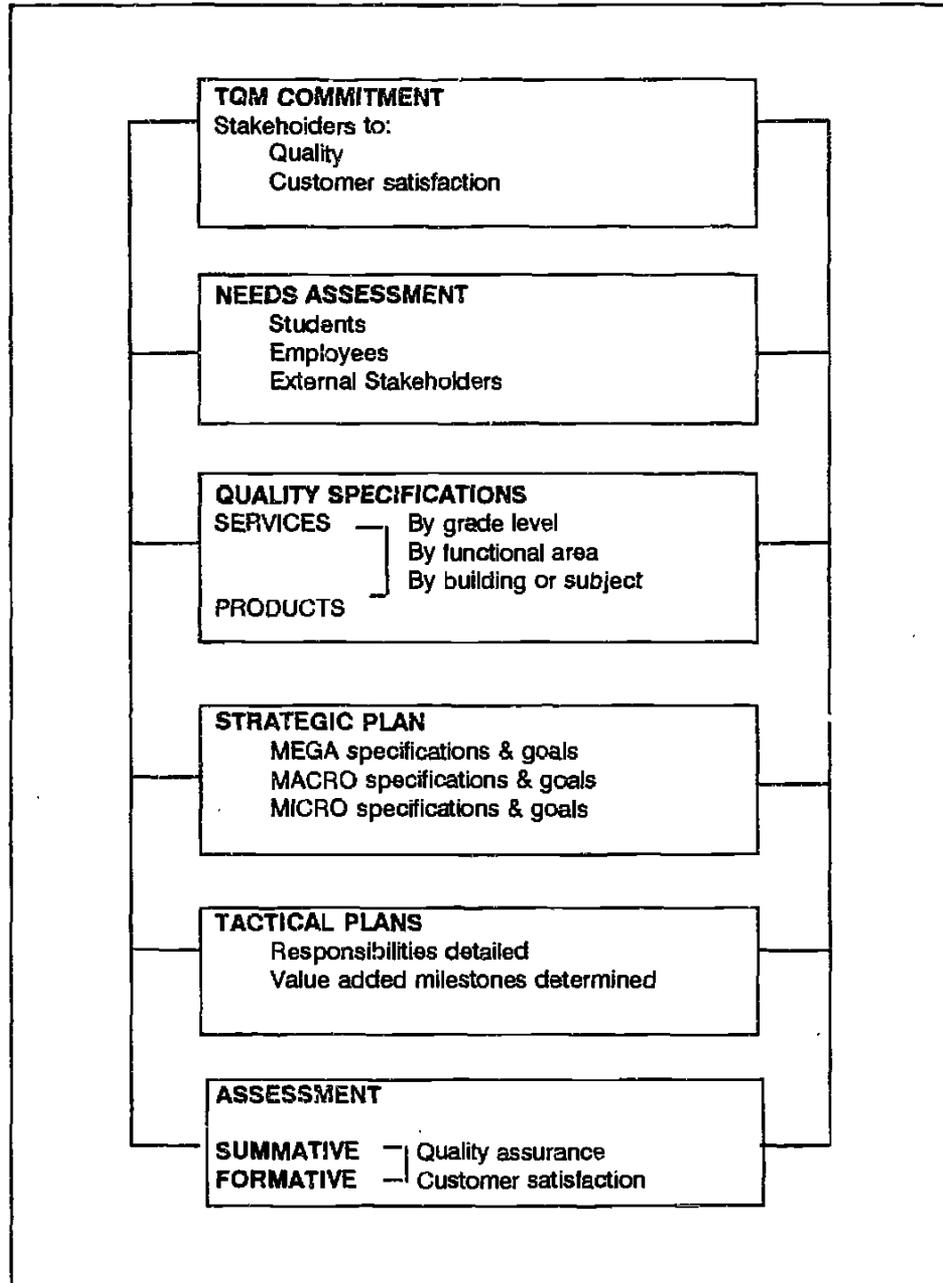
"Educational stakeholders must realize that school districts are systems which are comprised of a series of sub-systems, and the sooner these sub-systems work collaboratively together to develop an effective and efficient total school district system, the quicker the school district will develop high quality services and products which will please all categories of its customers." (Herman,1992; p.27)

These words characterize the philosophy of a true systems thinking approach to education that is needed today to bring about the long sought after transformation of education that will put American schools back at the forefront of education, globally. Herman has adapted the principles of TQM to education through an approach that "begins with a commitment to quality and customer satisfaction, using TQM as the means to accomplish these goals..."(ibid., p. 21.)

Herman's TQM model for school systems is depicted in figure 2. This overall systems view contains the following five subsystems: TQM employee sub-system, TQM student sub-system, TQM external environmental sub-system, TQM strategic planning process subsystem, and TQM tactical process sub-system. An important feature common to all of these sub-systems is that of an *assessment component* which provides the basis for a "recycle" or feedback loop to the system to support continuous improvement of the sub-system's processes and outputs. Herman's model employs both *formative* and *summative* assessments in each of its five sub-systems.

(Insert figure 2, TQM model for school districts about here.)

Figure 2. TQM Model for School Districts



Adapted from Herman, J., 1992.

Herman's TQM Student Sub-system is of the greatest interest insofar as assessment of student achievement is concerned. This sub-system contains the essential features found in more recent approaches to education based on certification of student performance, such as "outcome based education" and "standards based education." As shown in figure 3, outcome based quality specifications for student achievement are first determined then quality achievement specifications for individual students are developed. Instruction is provided based on the desired outcomes and quality standards, and the quality of learning is then assessed.

(Insert figure 3, TQM Student Sub-system about here)

An open system view of education.

Dolan, Banathy, Herman, Betts and Sarason correctly identify an education system as being comprised of sub-systems that interact, require communication and process information. A critical feature of each of these views is that the system defined by them is, at least ideally, an open system. Figure 4 graphically depicts a school system as an open system, the most significant unit of which is the individual school. Alternatively one could focus on the classroom or the administrative structure of the system and by so doing derive a different, though equally valid perspective.

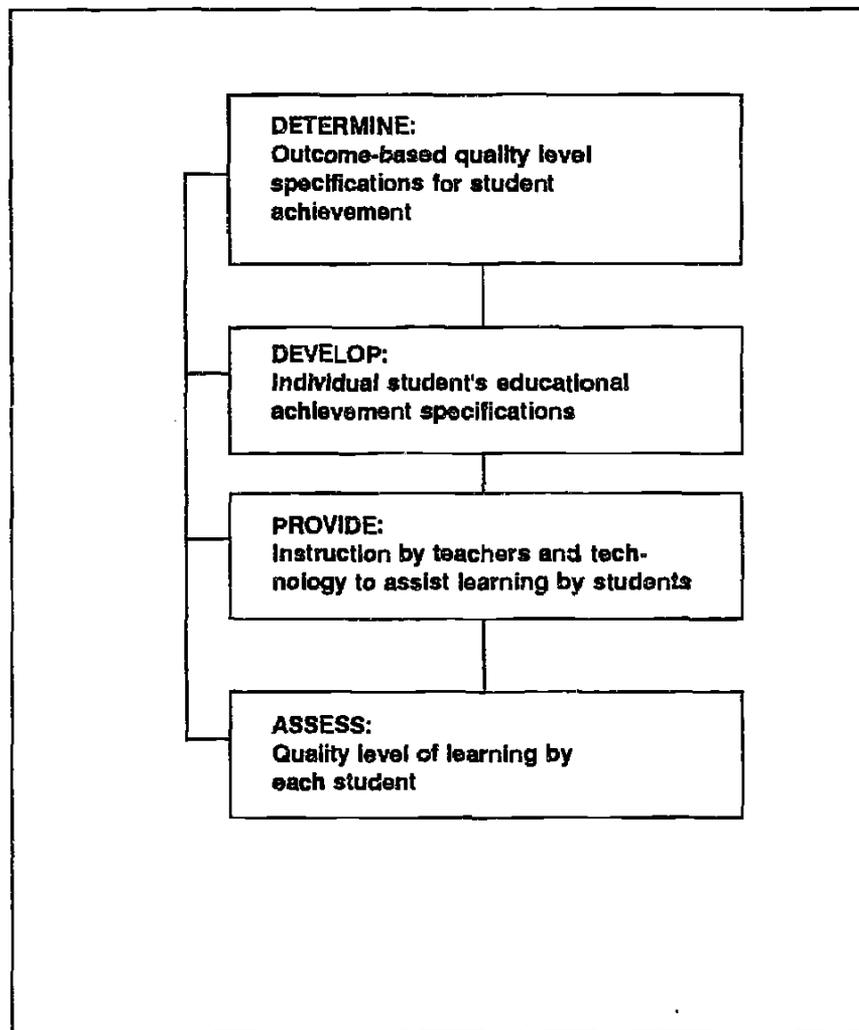
(Insert figure 4, An open system depiction of a school system about here.)

Figure 4 illustrates an open system view of a school district in which a number of sources of input and energy exert their influence and create the system dynamics. In this view the school system appears as an interdependent teleological system. That is to say, it is a system with a definite purpose, the education of the child, pupil or student. All resources are directed toward this end. External sources of energy include state and federal government, "the public", business and industry, changes in societal values, legally mandated site councils and advisory committees. Internal sources include professional associations/unions, employee groups, and structural levels (e.g. elementary, middle and high school).

Major sub-systems, their interfaces and information needs

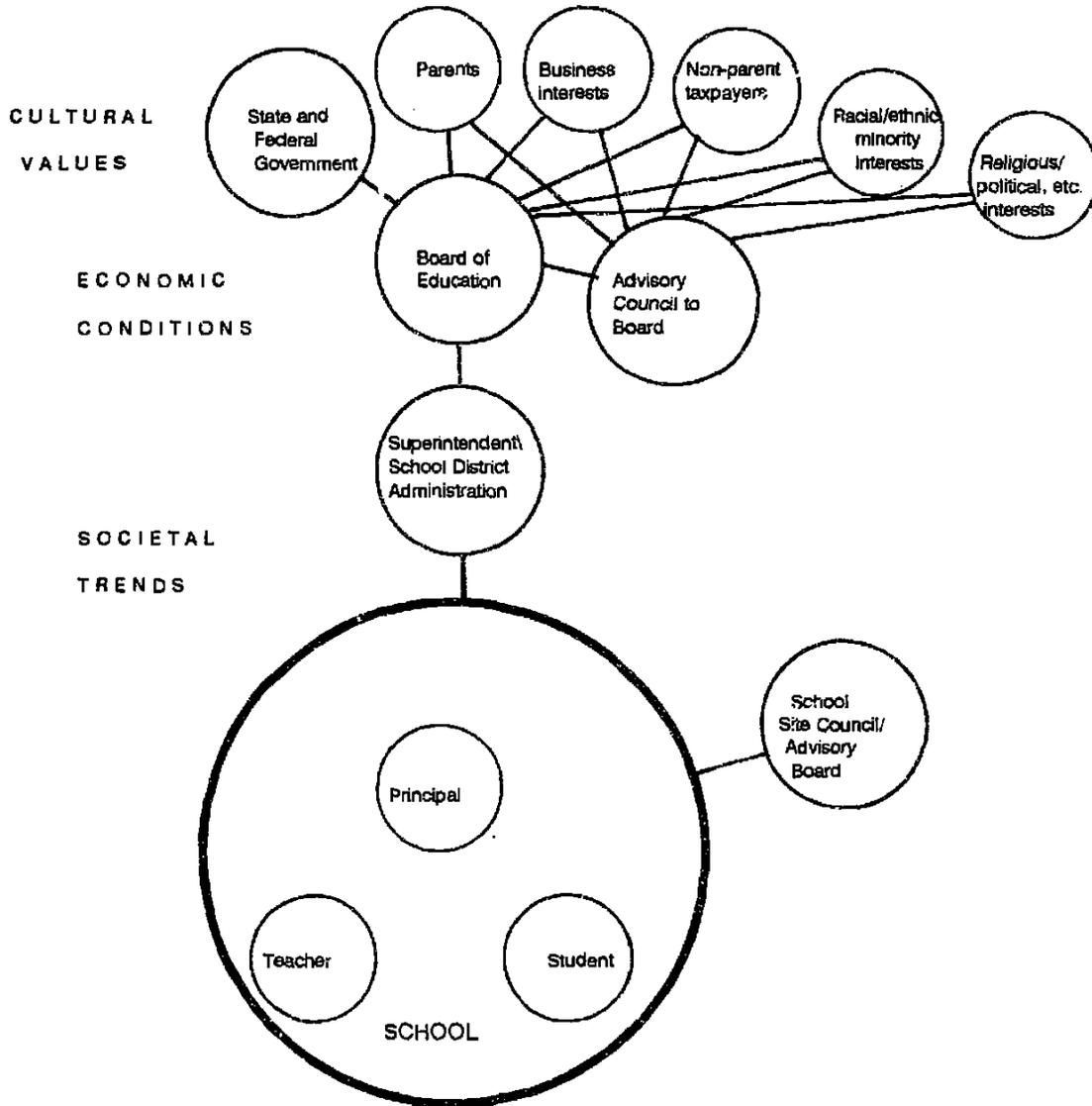
As described by Sarason, Dolan, Banathy, and Herman, an education system is comprised of various sub-systems each of which performs a vital function for the supra-system, and each of which interfaces with other sub-systems through the flow of information and energetic input. The major organizational sub-systems and interfaces in this open system view of education are:

- Policy level: board of education - public and administrative interface; responsible for policy guidance and maintaining a connection with the values and interests of the community at large.
- Administrative managerial level: superintendent and central administration, interfaces with board of education, school administration and the public through open meetings and advisory groups; responsible for maintaining system integrity through sound fiscal management, providing and developing leadership, developing curriculum, providing vital support functions, monitoring system effects, reporting results and assuring compliance with legal mandates.
- Operational level: individual school, includes principal, teaching staff, support staff, and students, interfaces with parents, advisory groups, PTO/PTA, etc.; responsible for maintaining safe and orderly learning environment and teaching students.

FIGURE 3. TQM Student Sub-system

Adapted from Herman, J., 1992

Figure 4. Open system depiction of a school system



Policy Level. Each of these sub-systems has information needs that derive from its purpose or central mission and these information needs vary across sub-systems in terms of both content and level of detail (Hansen, 1992), as illustrated in figure 5. For example, the board of education as the main policy body exists for the purpose of representing the general public in the formulation of policy decisions to guide the district administration. This purpose requires a broad perspective in which the needs of the taxpayers and the needs of the students are viewed simultaneously and balanced against each other. The board must stay focused on the big picture of the needs of the entire system. Therefore the board's information need is for summary information about the larger issues that affect the district as a whole, such as enrollment growth trends which might have implications for building new schools or closing old ones. They need information on how well the students in the district are achieving with respect to the broad outcomes in critical areas of learning, such as the basic skills, thinking skills, social studies, science, etc. And they need information on the extent to which the students are being prepared adequately for their major life roles of worker, life-long learner, and responsible citizen. By contrast the board of education does not need information on the achievement or performance of individual students, or staff unless that performance has implications for district policy. Nor do they need line item information about the budget. They do need information that tells them the extent to which the District's planned and actual spending supports the broad policy goals, educational priorities and strategic plan directions they have established for the district.

(Insert figure 5 about here.)

Administrative-managerial level. At the administrative-managerial level sub-system information needs are more intensive in both the scope and level of detail required, than at the board level. Program managers need information on the success of their programs in teaching students their content and processes. Department heads need detailed information on their expenditures relative to their allocated budget. Curriculum supervisors need information on the degree to which the curriculum is being implemented effectively and how well it is working in terms of student learning and teacher acceptance. Assistant superintendents or cluster leaders need information on the effectiveness of the schools under their supervision, in successfully teaching students the specified outcomes, as well as information on the performance of the principals they supervise, and so on. The feedback this sub-system requires from the system is used to make short term or tactical adjustments as well as to plan for longer term or strategic goals. Therefore the information used at this level must contain more detail than that required at the policy level.

Operational Level The information needs at the school level are narrower, focusing more on what is happening within this sub-system and between it and the other sub-systems with which it interfaces. More detailed information on student performance is needed by teachers who must constantly assess the extent to which individual students are learning what they need to know and be able to do, and use the information they collect through the assessment process to make adjustments in their instructional plans.

The principal needs information on how well this year's fifth grade is doing in math relative to previous cohorts and external referents. He or she also needs to know how well the school is doing in meeting the goals it has set for the year and how well each teacher or instructional team is doing.

In summary, the information needs of these major sub-systems for policy, administration and operations vary in both content and level of detail, with the greater need for detail occurring at the school level and even more so at the classroom level within the school. The information content and detail required by a sub-system are a function of the purpose of the sub-system and the types of decisions that must be made by the people within that sub-system. I have discussed this relationship elsewhere (Hansen, 1992) and have shown that the need for information forms a gradient that varies from fine-grained detailed information at the classroom level to coarse-grained summary information at the policy level as shown in figure 5.

Student Performance Information Needs. An important common element in the information needs of these sub-systems is information on student performance and achievement with respect to the generally agreed upon learning outcomes, goals or standards of achievement. Assessment of student achievement and performance plays a vital role in the education system by providing useful information to decision makers at all levels of the decision hierarchy on the success of the system as described by adopted system standards.

The relationship between type of student performance information needed and hierarchical level of the system by which it is needed is illustrated in a flow diagram in figure 6 below.

(Insert figure 6 about here.)

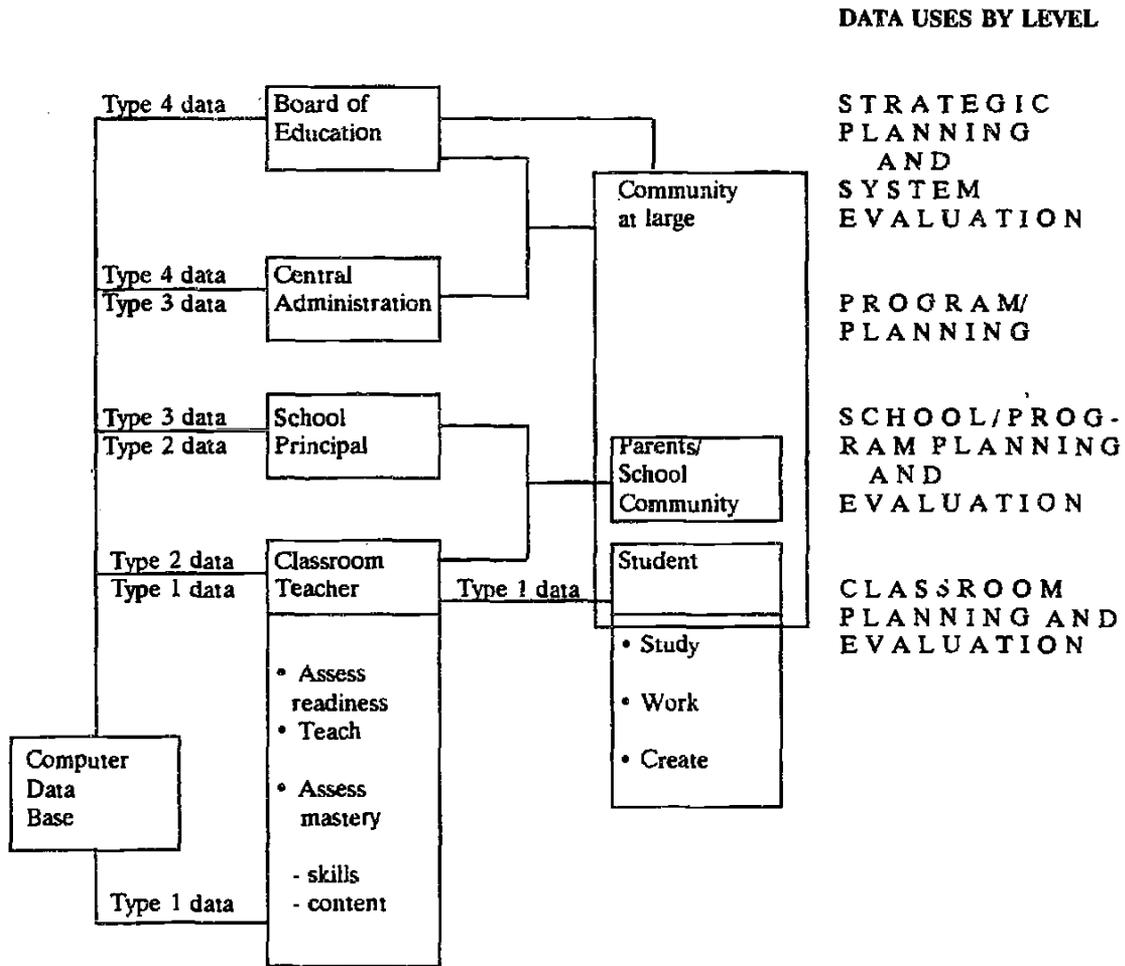
As shown in figure 6, the board of education is responsible to the community-at-large, from which it receives energetic input in the form of votes, protests, statements of support and other information. The community, in turn, receives information from the board about how well the school district as a whole is performing its mission of educating students.

SUMMARY AND CONCLUSIONS

This paper has introduced the reader to some fundamental systems theory concepts and applied those concepts to an educational system. My hopes are that: 1) educators with some responsibility for designing, redesigning or reforming educational systems will begin to view those systems somewhat differently - more systemically, as complex, pluralistic open and teleologic systems, and 2) that professional educators, policy makers, students and interested members of the general public will recognize the complexities of the educational systems they interact with and will begin to apply these concepts and principles as they think about educational reform. The frequent and sometimes naive use of systems terms when referring to educational reform efforts indicates that there is a need for a better understanding by educational reform advocates, of the principles of systems theory. Understanding an education system in systems theory terms and recognizing the role of an assessment sub-system as a vital component for obtaining feedback on student performance with respect to important learning outcomes can help educational reformers to make the most appropriate use of this sub-system to obtain the maximum effectiveness from the system.

Whether one takes a position similar to that of Banathy(1991) which calls for the total redesign of American public education, or a more moderate position of improving education through incremental change, it is crucial to the success of any reform effort that a systems view prevails in order for the planned reforms to be maximally effective. This is true because of the complex interrelationships that exist among sub-systems and between a system and its environment. It is also true because systems have the capability of sealing off structural and process changes affecting a single sub-system and developing new sub-systems which help them maintain their long-term dynamic homeostasis consistent with their established teleology. A well established system can maintain this dynamic homeostasis and resist change efforts if those efforts address only one or a few of its sub-systems. Therefore educational reformists must understand how the sub-systems work to maintain the system and must consciously anticipate the effects of their efforts on specific sub-systems and the consequent effects of the changed sub-systems on other sub-systems with which they interact. Reformists also need to carefully analyze and understand the information needs of the system and the way the system exchanges information with its environment if their reform efforts are to succeed.

Figure 6. Flow diagram of assessment data subsystem



Types of data

- Type 1 data: Individual student
- Type 2 data: Instructional group, class within a school
- Type 3 data: Grade level, age cohort within a school
- Type 4 data: Grade level, age cohort across schools

A GENERIC MODEL FOR EDUCATIONAL REFORM

The systems theory principles discussed in this paper have implications for a generic model for school reform. Such a model must have, as a minimum, the following features.

1. **An open system view of education.** In order for reform to be effective it must recognize the open nature of education systems and take advantage of the implications this has for importation of energy and information and the effective use of that energy and information.
2. **Recognition of the System's Vision, Mission and Goals.** Teleology plays a major role in systems theory and is of major importance to a school district. Not only must the system's vision, mission and goals be clearly stated and understood by all those within the system, it must also be clearly communicated to the system's clients - the students, community members, parents and others who by virtue of their roles have a vital stake in the system's success.
3. **Alignment of the Vision, Mission and Goals of individuals within the system with the system's Vision, Mission and Goals.** All energy within the system must be focused on the common purpose defined by the V,M and G statements. To the extent that an individual within the system fails to perceive or understand the relationship between his/her goals and objectives and those of the system as a whole, he may become a source of unfocused or diffuse energy that creates resistance or friction within the system. Frequent review by managers, of these relationships and their importance to the overall effectiveness of the system is therefore essential.
4. **Well defined methods for promoting communication across barriers and breaking down communication barriers where they do exist.** Effective, two-way information flow is crucial to the successful functioning of a pluralistic, open, social system. The hierarchical barriers especially must be consciously dealt with by developing structural mechanisms for bridging them. Barriers between organizational units can be breached by inter-unit communication teams designed to share information on issues of common concern. Barriers between the subsystems and the environment can be breached with public forums, citizen advisory groups and town meetings or focus groups.
5. **Feedback mechanisms or thermostats to assist in maintaining dynamic homeostasis.** Related to, but not the same as communications, this feature requires multiple structural approaches to obtaining input from the internal and external environment on the extent to which the system as a whole, as well as its individual sub-systems is meeting its goals and fulfilling its mission. Just as a thermostat constantly monitors the environment for discrepancies, these mechanisms must also work continuously to collect and process information on systemic effectiveness.
6. **Action producing mechanisms to analyze environmental feedback and design the most effective corrective action.** These could be action research teams (ART) comprised of representatives from various units within the system as well as representatives from the public. The function of these ARTs would be to analyze the feedback obtained through the monitoring process and make recommendations to the Board of Education or the executive leadership on what to change and how to change it. These recommendations must take into account the effect of a changed sub-system on other sub-systems.

While these features may not include all of the possible desirable characteristics of a systems model, they at least provide a framework within which systemic change can be monitored and governed. The specific details of such a model would necessarily vary in response to variations in local system needs.

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