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How Systems Thinking Applies to Education

Frank Betts

Nearly a century of change has left schools playing catch-up, and it will take a whole-system approach to meet society's evolving needs.

Our piecemeal change efforts of the last decade have taught us a valuable lesson about Total Quality Management: we must seek improvement through systemic change. Current approaches to solving problems in education are the same ones used by generations of educators and are stoutly defended as having worked in the past. But we can now see clearly that the environment within which education is embedded has been changing at an increasing rate since about 1900. It wasn't until 1950 that the magnitude of change became evident and stimulated a series of reforms, which have had little apparent impact (Banathy 1991).

Currently, the call for systemic change in education is becoming increasingly strident. 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 as one. Many people say they are using a systems approach, but almost no one really is. Furthermore, popular interpretations of systems tend to use inappropriate mechanical models and metaphors. Decision makers need to fully understand why our current approaches won't work and what is different about the systems approach.

Current Approaches

The seeds of public education's current failures are found in its success in the past. From its inception, public education has been called on to transmit core knowledge and cultural values, provide custodial care, and prepare students for life after school, the most important aspect of which is critical and creative thinking for problem solving and decision making. Public education has been very successful in its first function, generally successful in the second, and much less successful in the last. As a consequence, public education has emerged as one of the prime sources of stability, or pattern maintenance, in our society. Public education's overwhelming success as a pattern maintenance institution is at the heart of its failure to match changing societal expectations.

Banathy (1991) suggests five reasons why our efforts to make a transition have met with so little success:

- the piecemeal, or incremental, approach;
- failure to integrate solution ideas;
- a discipline-by-discipline study of education;
- a reductionist orientation;
- staying within the boundaries of the existing system (not thinking out of the box).

All five are examples of *paradigm paralysis*, or *mumpsimus*, which Webster defines as "persistence in a mistaken belief," the attempt to interpret current experience using old models and metaphors that are no longer appropriate or useful. An examination of the key evolutionary makers in Figure 1 illustrate that our schools remain firmly rooted at Stage 3, when the rest of the world has moved into Stage 4.

If the old paradigms won't work, something fundamentally better suited to the task is needed, a paradigm that illuminates the whole, not just the parts; one that is synthetic, rather than analytic; one that integrates, rather than differentiates. This new paradigm is systems thinking.

Systems Definitions

Even a small child can use a hammer and saw, but it takes a master carpenter who fully understands the tools and their limitations to build a house. We can begin to build a few structures of our own by establishing some definitions for terms needed to discuss systems thinking meaningfully.

A *system* is a set of elements that function as a whole to achieve a common purpose. A *subsystem* is a component of a larger system; for example, the circulatory system is a subsystem of a human system. Occasionally, the larger system is referred to as a *supra-system* when it is talked about in relation to its subsystems.

An *element* is a necessary but not self-sufficient component of a system. That is, the system cannot achieve its purpose without the element, and the element by itself cannot replicate the system's functions.

Systems are characterized by *synergy*—the whole (system) is greater than the sum of its parts (elements), because the relationship among the elements adds value to the system.

The relationship among the elements is maintained by an

Figure 1

Key Evolutionary Markers

Stage 1	Stage 2	Stage 3	Stage 4
hunter gathering groups	agricultural societies	industrial society	post-industrial society
500,000 years	10,000 years	500 years	50 years
speech	writing	print	cybernetic technology
wandering tribes	communities city-states	nation-states	potential of a global society
magico-mythic paradigm	logico-philosophical paradigm	deterministic scientific paradigm	systemic change paradigm
survival technology	fabricating technology	machine technology	intellectual technology
subsistence	barter	money	credit/debit
nomadic subsistence	cottage industry	factory	electronic village
oldest member	best farmer	capitalist	information source
words	graphics	analogue	digital data

Adapted from *Systems Design of Education: A Journey to Create the Future*, Bela H. Benathy, 1991, Educational Technology Publications, Inc., Englewood Cliffs, New Jersey. Used with permission of the publisher.

exchange of *energy*; for example, money in a banking system, heat in a thermodynamic system, or information in a learning system. The relationship among elements is maintained by a difference in energy potential among elements, which allows for an interchange. A healthy system is constantly searching for a dynamic balance through self-regulating mechanisms. For example, the human system maintains body temperature in a dynamic balance around 98.6 degrees Fahrenheit by increasing or decreasing the circulation of blood near the *system boundary* (skin) through shivering, panting, or perspiring.

The total quantity of energy in a system is fixed; however, energy is constantly redistributed among subsystems. Individually, all systems and subsystems are subject to *entropy*, the process by which energy becomes distributed evenly throughout the system. When there is no longer a difference in energy levels among subsystems or elements, the system breaks apart or dies.

To continue to exist, a system must be able to import energy across its boundary or have a capacity to create new sources of energy. A system that is able to import and export energy is called an *open system*. One that cannot import energy is called a *closed system*. A closed system that cannot generate a sufficient amount of energy internally to replace what is lost to entropy will die. A recent dramatic example of this is the demise of the U.S.S.R., a closed political system. The Soviet Union simply required more energy to maintain itself than could be generated internally or imported.

With these definitions and examples in mind, we can see why general solutions to educational problems do not work. Each educational system is composed of a unique set of elements arranged in a unique constellation of relationships. Furthermore, the relationships among elements, subsystems, and supra-systems are continually changing in search of equilibrium while avoiding entropy.

Open Systems

Social systems such as a school are generally regarded as open systems. Katz and Kahn (1966) have defined the attributes of an open system.

- Energy is transformed, and something new is produced.
- A product is exported into the environment.
- The pattern of energy exchange is cyclical; the product that is exported into the environment is the source of energy for repetition of the cycle of activities.
- The system aims to "maximize its ratio of imported to expended energy."
- The system exhibits differentiation, a tendency toward increased complexity through specialization.

In addition to the degree of openness, systems are also characterized by three important concepts: hierarchy, homeostasis, and purposiveness.

Hierarchy. A system's hierarchy refers to the number of levels within the system. Each successively higher level of the hierarchy encompasses all of the processes at each lower level and is increasingly complex as the number of elements and the relationship among elements increases. As the number of elements, or subsystems, increases linearly, the number of relationships increases exponentially. What is of particular significance from

the systems perspective is that the energy required to maintain the relationships increases at an even faster rate.

Hierarchies may be natural, for example, birth order in a family, or arbitrary, as is the case in a designed system, such as a school or business. Arbitrary hierarchies require more energy to maintain than do natural hierarchies, and they frequently divert energy from goal attainment. For example, maintaining the age-grade hierarchy is schools can be shown to be counterproductive in many cases.

Furthermore, Kenneth Boulding has suggested a useful rule-of-thumb related to hierarchies. For example, if a teacher is having problems in classroom management (classroom level), we tend to discuss the difficulties in terms of the teacher's behaviors (individual level), but the solution may be more readily found at the school level in the nature of the supportive structures, unrealistic expectations of teachers, or even the notion of a classroom itself. Russell Ackoff suggests the most elegant way to handle a problem is to dissolve it. The only way an individual teacher can have problems of classroom management is if instruction has been arbitrarily organized into teacher-managed self-contained classrooms.

Homeostasis. A second important characteristic is homeostasis, which refers to self-regulation through feedback mechanisms. Machines are relatively simple systems with few variables, which operate in a stable relationship. Mechanical systems require little feedback from the environment to function.

At the other extreme, organic systems are very complex with many variables, which require a great deal of feedback. The larger and more complex the system, the more energy, in the form of feedback, is required to maintain a dynamic balance among elements.

Purposiveness. A final characteristic of a system is it purposiveness.

The inevitable conclusion from the evidence at hand is that the old system is no longer adequate to the task.

Some systems have a single, clear goal, which Banathy (1991, p. 35) classifies as a "unitary" system. Other systems have many, sometimes even conflicting, goals; these are "pluralistic" systems.

We have attempted to treat education as a unitary system, but in reality it is highly pluralistic with many conflicting goals. The compromises that we have reached by applying old paradigms in a new context are proving to be unsatisfactory, but paradigm paralysis prevents us from seeing what is really needed. By placing systems along a descriptive continuum for each characteristic, we can better differentiate between system types.

Schools as Open Systems

As a system, a school is moderately open. The primary types of energy are financial and intellectual. The school is not a natural system; it operates under a series of sometimes conflicting legal mandates rather than a social mandate that represents a consensus of the participants. Consequently, substantial amounts of systems energy are consumed in maintaining relationships rather than achieving goals.

Similarly, schools tend to be more mechanistic than organic, as evidenced by rigid structures that tend to treat all elements similarly: class periods of fixed length, a single textbook for all students in a class, classes of the same size for different subjects, and so on.

Schools, as proposed earlier, have a limited set of goals: the same goals for each student. While they are unitary in character with respect to goals, schools generally have some latitude with respect to the means to achieve those goals.

Finally, schools have a restricted hierarchy with relatively few levels of complexity. The more constraints under which a school must work, such as legislative mandates or environmental pressures in the form of racial tensions, drug abuse, or poverty, the more closed, mechanistic, unitary, and restricted they become.

The improvement of quality involves the design of an educational system that not only optimizes the relationship among the elements but also between the educational system and its environment. In general, this means designing a system that is more open, organic, pluralistic, and complex. Banathy (1991, p. 80) has described such a system.

- It interacts with constantly changing (multiple) environments and coordinates with many other systems in the environment.
- It copes with constant change, uncertainty, and ambiguity while maintaining the ability to co-evolve with the environment by changing itself and transforming and the environment.
- It lives and deals creatively with change and welcomes—not just tolerates—complex and ambiguous situations.
- It becomes an organizational learning systems, capable of differentiating among situations where maintaining the organization by adjustments and corrections is appropriate (single-loop learning) and those where changing and redesigning are called for (double-loop learning) (Argyris 1982).
- It seeks and finds new purposes, carves out new niches in the environment, and develops increased capacity for self-reference, self-correction, self-direction, self-organization, and self-renewal.

- It recognizes that the continuing knowledge explosion requires a two-pronged increase in specialization and diversification *and* integration and generalization.
- It increases the amount of information it can process, processes it rapidly, distributes it to a larger number of groups and people, and transforms the information into organizational knowledge.

Implications for Education

The inevitable conclusion from the evidence at hand is that the old system is no longer adequate to the task. If we accept this assertion, we must also conclude that no amount of fine-tuning of the old system will produce significant improvement. What kind of a system is needed to produce the breakthrough achievement we are looking for?

An analysis of the literature and practice in both educational and management suggests we are moving from deterministic systems toward purpose-seeking systems. In social terms, we are moving from "dictatorial" to "participative" organizational styles.

In order to make this kind of transition, it is necessary only to shift perspective from a *one-to-many* toward a *many-to-one* orientation. For example, in education this means a shift from viewing education as a system in which one teacher provides information to many students toward a system in which there are many information resources accessible by one student, only one of which is the teacher. This shift can accurately be characterized as moving from an emphasis on instruction to an emphasis on learning.

From the perspective of systemic change, the implications of this idea are huge. Clearly, there is no place in the new system design for the old "2-4-6 model": all information between two textbook covers, taught within four walls, in six periods. Equally clearly, the new designs will include an increasing number of the following elements:

- outcomes (broad statements of purpose);
- outcome-related standards;
- benchmarks for each standard against which to measure individual and program progress continuously;
- assessment based on performance compared to benchmarks, not to other students (feedback);
- self-assessment;
- triangulation (use of multiple forms of assessment by multiple assessors to increase the validity and reliability of feedback);
- immediate intervention;
- generative learning (Wittrock 1974);
- reflective practice (Schon 1987, *Educational Leadership* 1991);
- balanced instructional design (Betts and Walberg, unpublished manuscript);
- varied learning structures (self-directed, one-to-one, small groups, lecture, field study, apprenticeships, mentoring);
- year-round schooling;
- assignment to learning groups based on individual performance, rather than age-grade distinctions;
- intact teams working over an extended period of time (more than one year) to achieve a common goal;
- increased sources of information via telecommunications from school and home, through peer and cross-age relationships, using cooperative learning structures, from video and optical media, supported by fully integrated, interactive computer-assisted instruction through a variety of electronically linked community resources (home, school, work, libraries, recreation centers, health care facilities, churches);
- increased access to information;
- digitized student information and instructional resources, fully accessible via touch-tone phone;
- "electronic books";
- multilingual resources;
- multimedia delivery (sound, graphics, and/or text options);
- tightly integrated curriculum, instruction, and assessment, such as total immersion second language instruction;
- hierarchy of small, six-to-eight person, self-sufficient, semiautonomous teams (sub-systems).

These are not completely new elements; however, the effort to incorporate all of these elements in a designed system has not been made. Total Quality Management in education means a total systems approach and, as it appears increasingly apparent, a totally new system. ■

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