3. SYSTEMS INQUIRY AND ITS APPLICATION IN EDUCATION

Bela H. Banathy
INTERNATIONAL SYSTEMS INSTITUTE

3.1 PART 1: SYSTEMS INQUIRY

The first part of this chapter is a review of the evolution of the systems movement and a discussion of human systems inquiry.

3.1.1 A Definition of Systems Inquiry

Systems inquiry incorporates three interrelated domains of disciplined inquiry: systems theory, systems philosophy, and systems methodology. Bertalanffy (1968) notes that in contrast with the analytical, reductionist, and linear-causal paradigm of classical science, *systems philosophy* brings forth a reorientation of thought and world view, manifested by an expansionist, nonlinear dynamic, and synthetic mode of thinking. The scientific exploration of systems theories and the development of systems theories in the various sciences have brought forth a *general theory of systems,* a set of interrelated concepts and principles, applying to all systems. *Systems methodology* provides us with a set of models, strategies, methods, and tools that instrumentalize systems theory and philosophy in analysis, design, development, and management of complex systems.

3.1.1.1. Systems Theory. During the early 1950s, the basic concepts and principles of a general theory of systems were set forth by such pioneers of the systems movement as Ashby, Bertalanffy, Boulding, Fagen, Gerard, Rappoport, and Wienner. They came from a variety of disciplines and fields of study. They shared and articulated a common conviction: the unified nature of reality. They recognized a compelling need for a unified disciplined inquiry in understanding and dealing with increasing complexities, complexities that are beyond the competence of any single discipline. As a result, they developed a transdisciplinary perspective that emphasized the intrinsic order and interdependence of the world in all its manifestations. From their work emerged systems theory, the science of complexity. In defining systems theory, I review the key ideas of Bertalanffy and Boulding, who were two of the founders of the Society for the Advancement of General Systems Theory. Later, the name of the society was changed to the Society for General Systems Research, then the International Society for Systems research, and recently to the International Society for the Systems Sciences.

3.1.1.1.1. Bertalanffy (1956, pp. 1—10). He suggested that "modem science is characterized by its ever-increasing specialization, necessitated by the enormous amount of data, the complexity of techniques, and structures within every field. This, however, led to a breakdown of science as an integrated realm. "Scientists, operating in the various disciplines, are encapsulated in their private universe, and it is difficult to get word from one cocoon to the other." Against this background, he observes a remarkable development, namely, that "similar general viewpoints and conceptions have appeared in very different fields." Reviewing this development in those fields, Bertalanffy suggests that there exist models, principles, and laws that can be generalized across various systems, their components, and the relationships among them. "It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general."

The first consequence of this approach is the recognition of the existence of systems properties that are general and structural similarities or isomorphies in different fields:

> There are correspondences in the principles which govern the behavior of entities that are intrinsically widely different. These correspondences are due to the fact that they all can be considered, in certain aspects, "systems," that is, complexes of elements standing in interaction. [It seems] that a general theory of systems would be a useful tool providing, on the one hand, models that can be used in, and transferred to, different fields, and safeguarding, on the other hand, from vague analogies which often have marred the progress in these fields.

This paper is dedicated to the memory of my dear friend and colleague, Kenneth Boulding, one of the founders of the systems movement and the first president of the Society for General Systems Research.

The second consequence of the idea of a general theory is to deal with organized complexity, which is a main problem of modern science.

> Concepts like those of organization, wholeness, directiveness, teleology, control, self-regulation, differentiation, and the like are alien to conventional science. However, they pop up everywhere in the biological, behavioral, and social scrences and are, in fact, indispensable for dealing with living organisms or social groups. Thus, a basic problem posed to modern science is a general theory of organization. General Systems Theory is, in principle, capable of giving exact definitions for such concepts.

Thirdly, Bertalanffy suggested that it is important to say what a general theory of systems is not. It is not identical with the triviality of mathematics of some sort that can be applied to any sort of problems; instead "it poses special problems that are far from being trivial." It is not

> a search for superficial analogies between physical, biological, and social systems. The isomorphy we have mentioned is a consequence of the fact that, in certain aspects, corresponding abstractions and conceptual models can be applied to different phenomena. It is only in view of these aspects that system laws apply.

Bertalanffy summarizes the aims of a general theory of systems as follows:

> (a) There is a general tendency towards integration in the various sciences, natural and social. (b) Such integration seems to be centered in a general theory of systems. (c) Such theory may be an important means of aiming at exact theory in the nonphysical fields of science. (d) Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of sciences. (e) This can lead to a much needed integration in scientific education.

Commenting later on education, Bertalanffy noted that education treats the various scientific disciplines as separate domains, where increasingly smaller subdomains become separate sciences, unconnected with the rest. In contrast, the educational demands of scientific generalists and developing transdisciplinary basic principles are precisely those that General Systems Theory (GST) tries to fill. In this sense, GST seems to make an important headway toward transdisciplinary synthesis and integrated education.

3.1.1.1.2. Boulding (1956, pp. 11—17). He underscored the need for a general theory as he suggested that in recent years increasing need has been felt for a body of theoretical constructs that will discuss the general relationships of the empirical world.

> This is the quest of General Systems Theory (GST). It does not seek, of course, to establish a single, self-contained "general theory of practically everything" which will replace all the special theories of particular disciplines. Such a theory would be almost without content, and all we can say about practically everything is almost nothing.
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> Somewhere between the specific that has no meaning and the general that has no content there must be, for each purpose and at each level of abstraction, an optimum degree of generality.

The objectives of GST, then, can be set out with varying degrees of ambitions and confidence. At a low level of ambition, but with a high degree of confidence, it aims to point out similarities in the theoretical constructions of different disciplines, where these exist, and to develop theoretical models having applicability to different fields of study. At a higher level of ambition, but perhaps with a lower level of confidence, it hopes to develop something like a "spectrum" of theories—a system of systems that may perform a "gestalt" in theoretical constructions. It is the main objective of GST, says Boulding, to develop "generalized ears" that overcome the "specialized deafness" of the specific disciplines, meaning that someone who ought to know something that someone else knows isn't able to find it out for lack of generalized ears. Developing a framework of a general theory will enable the specialist to catch relevant communications from others.

In the closing section of his paper, Boulding referred to the subtitle of his paper: GST as "the skeleton of science. It is a skeleton in the sense—he says—that:

> It aims to provide a framework or structure of systems on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge. It is also, however, something of a skeleton in a cupboard—the cupboard in this case being the unwillingness of science to admit the tendency to shut the door on problems and subject matters which do not fit easily into simple mechanical schemes. Science, for all its success, still has a very long way to go. GST may at times be an embarrassment in pointing out how very far we still have to go, and in deflating excessive philosophical claims for overly simple systems. It also may be helpful, however, in pointing out to some extent where we have to go. The skeleton must come out of the cupboards before its dry bones can live.

The two papers introduced above set forth the vision of the systems movement. That vision still guides us today. At this point it seems to be appropriate to tell the story that marks the genesis of the systems movement. Kenneth Boulding told this story at the occasion when I was privileged to present to him the distinguished scholarship award of the Society of General Systems Research at our 1983 Annual Meeting. The year was 1954. At the Center for Behavioral Sciences, at Stanford University, four Center Fellows—Bertalanffy (biology), Boulding (economics), Gerard (psychology), and Rappoport (mathematics) — had a discussion in a meeting room. Another Center Fellow walked in and asked: "What's going on here?" Ken answered: "We are angered about the state of the human condition and ask: 'What can we—what can science—do about improving the human condition? "Oh!" their visitor said: "This is not my field At that meeting the four scientists felt that in the statement of their visitor they heard the statement of the fragmented disciplines that have little concern for doing anything practical about the fate of humanity. So, they asked themselves, "What would happen if science would be redefined by crossing disciplinary boundaries and forge a general theory that would bring us together in the service of humanity?" Later they went to Berkeley, to the annual meeting of the American Association for the Advancement of Science, and established the Society for the Advancement of General Systems Theory. Throughout the years, many of us in the systems movement have continued to ask the question: How can systems science serve humanity?

3.1.1.2. Systems Philosophy. The next main branch of systems inquiry is systems philosophy. Systems philosophy is concerned with a systems view of the world and the elucidation of systems thinking as an approach to theoretical and real-world problems. Systems philosophy seeks to uncover the most general assumptions lying at the roots of any and all of systems inquiry. An articulation of these assumptions gives systems inquiry coherence and internal consistency. Systems philosophy (Laszlo, 1972) seeks to probe the basic texture and ultimate implications of systems inquiry. It "guides the imagination of the systems scientist and provides a general world view, the likes of which—in the history of science—has proven to be the most significant for asking the right question and perceiving the relevant state of affairs" (p. 10). The general scientific nature of systems inquiry implies its direct association with philosophy. This explains the philosophers' early and continuing interest in systems theory and the early and continuing interest of systems theorists and methodologists in the philosophical aspects of systems inquiry. In general, philosophical aspects are worked out in two directions. The first involves inquiry into the *What:* what things are, what a person or a society is, and what kind of world we live in. These questions pertain to what we call *ontology.* The second question is *How:* How do we know what we know; how do we know what kind of world we live in; how do we know what kind of persons we are? The exploration of these questions are the domain of epistemology. One might differentiate these two, but, as Bateson (1972) noted, ontology and epistemology cannot be separated. Our beliefs about what the world is will determine how we see it and act within it. And our ways of perceiving and acting will determine our beliefs about its nature. Blauberg, Sadovsky, and Yudin (1977) noted that the philosophical aspects of systems inquiry would give us an "unequivocal solution to all or most problems arising from a study of systems" (p. 94).

3.1.1.2.1. Ontology. The *ontological* task is the formation of a systems view of what is—in the broadest sense a systems view of the world. This can lead to a new orientation for scientific inquiry. As Baluberg (1977) noted, this orientation emerged into a holistic view of the world. Waddington (1977) presents a historical review of two great philosophical alternatives of the intellectual picture we have of the world. One view is that the world essentially consists of things. The other view is that the world consists of processes, and the things are only "stills" out of the moving picture. Systems philosophy developed as the main rival of the "thing view." It recognizes the primacy of organizing relationship processes between entities (of systems), from which emerge the novel properties of systems.

3.1.1.2.2. Epistemology This philosophical aspect deals with general questions: How do we know whatever we know? How do we know what kind of world we live in and what kind of organisms we are? What sort of thing is the mind? Bateson (1972) notes that originating from systems theory, extraordinary advances have been made in answering these questions. The ancient question of whether the mind is immanent or transcendent can be answered in favor of immanence. Furthermore, any ongoing ensemble (system) that has the appropriate complexity of causal and energy relationships will: (a) show mutual characteristics, (b) compare and respond to differences, (c) process information, (d) be self-corrective, and (e) no part of an internally interactive system can exercise unilateral control over other parts of the system. "The mutual characteristics of a system are immanent not in some part, but in the system as a whole" (p. 316).

The epistomological aspects of systems philosophy address: (a) the principles of how systems inquiry is conducted; (b) the specific categorical apparatus of the inquiry, and that connected with it; and (c) the theoretical language of systems science. The most significant guiding principle of systems inquiry is that of giving prominence to synthesis, not only as the culminating activity of the inquiry (following analysis) but also as a point of departure. This approach to the "how do we know" contrasts with the epistemology of traditional science that is almost exclusively analytical.

3.1.1.3. Systems Methodology. Systems methodology—a vital part of systems inquiry—has two domains of inquiry: (1) the study of methods in systems investigations by which we generate knowledge about systems in general and (2) the identification and description of strategies, models, methods, and tools for the application of systems theory and systems thinking for working with complex systems. In the context of this second domain, systems methodology is a set of coherent and related methods and tools applicable to: (a) the analysis of systems and systems problems, problems concerned with the systemic/ relational aspects of complex systems; (b) the design, development, implementation, and evaluation of complex systems; and (c) the management of systems and the management of change in systems.

The task of those using systems methodology in a given context is threefold: (1) to identify, characterize, and classify the nature of the problem situation, i.e., (a), (b), or (c) above; (2) to identify and characterize the problem context and content in which the methodology is applied; (3) to identify and characterize the type of system in which the problem situation is embedded; and (4) to select specific strategies, methods, and tools that are appropriate to the nature of the problem situation, to the context/content, and to the type of systems in which the problem situation is located.

The brief discussion above highlights the difference between the methodology of systems inquiry and the methodology of scientific inquiry in the various disciplines. The methodology of a discipline is clearly defined and is to be adhered to rigorously. It is the methodology that is the hallmark of a discipline. In systems inquiry, on the other hand, one selects methods and methodological tools or approaches that best fit the nature of the identified problem situation, and the context, the content, and the type of system that is the domain of the investigation. The methodology is to be selected from a wide range of systems methods that are available to us.

3.1.1.4. The Interaction of the Domains of Systems Inquiry. Systems philosophy, systems theory, and systems methodology come to life as they are used and applied in the functional context of systems. It is in the context of use that they are confirmed, changed, modified, and reconfirmed. Systems philosophy presents us with the underlying assumptions that provide the perspectives that guide us in defining and organizing the concepts and principles that constitute systems theory. Systems theory and systems philosophy then guide us in developing, selecting, and organizing approaches, methods, and tools into the scheme of systems methodology. Systems methodology then is used in the functional context of systems. But this process is not linear or forward-moving circular. It is recursive and multi-directional. One confirms or modifies the other. As theory is developed, it gets its confirmation from its underlying assumptions (philosophy), as well as from its application through methods in functional contexts. Methodology is confirmed or changed by testing its relevance to its theoretical / philosophical foundations and by its use. The functional context—the society in general and systems of all kinds in particular—is a primary source of placing demands on systems inquiry. It was, in fact, the emergence of complex systems that brought about the recognition of the need for new scientific thinking, new theory, and methodologies. It was this need that systems inquiry addressed and satisfied.

The dynamics of the recursive and multidirectional interaction of the four domains, described above, makes systems inquiry a living system. These dynamics are manifested in the interplay between confirmation and novelty. Novelty at times brings about adjustments and at other times it appears as discontinuities and major shifts. The process described here becomes transparent as the evolution of the systems movement is reviewed next.

3.1.2 The Evolution of the Systems Movement

Throughout the evolution of humanity there has been a constant yearning for understanding the wholeness of the human experience that manifests itself in the wholeness of the human being and the human society. Wholeness has been sought also in the disciplined inquiry of science as a way of searching for the unity of science and a unified theory of the universe. This search reaches back through the ages into the golden age of Greek philosophy and science in Plato's kybernetics, the art of steermanship, which is the origin of modern cybernetics: a domain of contemporary systems thinking. The search intensified during the Age of Enlightenment and the Age of Reason and Certainty, and it was manifested in the clockwork mechanistic world view. The search has continued in the current age of uncertainty (Heisenberg) and complexity, the science of relativity, (Einstein), quantum theory (Bohr & Shrodinger), and the theory of wholeness and the implicate order (Bohm).

In recent years, the major player in this search has been the systems movement. The genesis of the movement can be timed as the mid-50s (as discussed at the beginning of this chapter). But prior to that time, we can account for the emergence of the systems idea through the work of several philosophers and scientist.

3.1.2.1. The Pioneers. Some of the key notions of systems theory were articulated by the 18th-century German philosopher Hagel. He suggested that the whole is more than the sum of its parts, that the whole determines the nature of the parts, and the parts are dynamically interrelated and cannot be understood in isolation from the whole.

Most likely, the first person who used the term *general theory of systems* was the Hungarian philosopher and scientist Bela Zalai. Zalai, during the years 1913 to 1914, developed his theory in a collection of papers called *A Rendszerek Altalanos Elmelete.* The German translation was entitled *Allgemeine Theorie der Systeme* [General Theory of Systems]. The work was republished (Zalai, 1984) in Hungarian and was recently reviewed in English (Banathy & Banathy, 1989). In a three-volume treatise, *Tektologia,* Bogdanov (1921—1927), a Russian scientist, characterized *Tektologia* as a dynamic science of complex wholes, concerned with universal structural regularities, general types of systems, the general laws of their transformation, and the basic laws of organization. Bogdanov's work was published in English by Golerik (1980).

In the decades prior to and during World War II, the search intensified. The idea of a General Systems Theory was developed by Bertalanffy in the late 30s and was presented in various lectures. But his material remained unpublished until 1945 *(Zu einer allgemeinen Svstemlehre)* followed by "An Outline of General Systems Theory" (1951). Without using the term GST, the same frame of thinking was used in various articles by Ashby during the years 194S and 1947, published in his book *Design for a Brain,* in 1952.

3.1.2.2. Organized Developments. In contrast with the work of individual scientists, outlined above, since the 1940s we can account for several major developments that reflect the evolution of the systems movement, including "hard systems science," cybernetics, and the continuing evolution of a general theory of systems.

3.1.3 Hard-Systems Science

Under hard-systems science, we can account for two organized developments: operations research and systems engineering.

3.1.3.1. Operations Research. During the Second World War, it was again the "functional context" that challenged scientists. The complex problems of logistics and resource management in waging a war became the genesis of developing the earliest organized form of systems science: the quantitative analysis of rather closed systems. It was this orientation from which operations research and management science emerged during the SOs. This development directed systems science toward "hard" quantitative analysis. Operations research flourished during the 60s, but in the 70s, due to the changing nature of sociotechnical systems contexts, it went through a major shift toward a less quantitative orientation.

3.1.3.2. Systems Engineering. This is concerned with the design of closed man-machine systems and larger-scale sociotechnical systems. Systems engineering (SE) can be portrayed as a system of methods and tools, specific activities for problem solutions, and a set of relations between the tools and activities. The tools include language, mathematics, and graphics by which systems engineering communicates. The content of SE includes a variety of algorithms and concepts that enable various activities. The first major work in SE was published by A. D. Hall (1962). He presented a comprehensive, three-dimensional morphology for systems engineering. In a more recent work, Sage (1977) has changed the directions of SE.

> We use the word *system* to refer to the application of systems science and methodologies associated with the science of problem solving. We use the word *engineering* not only to mean the mastery and manipulation of physical data but also to imply social and behavioral consideration as inherent parts of the engineering design process (p. xi).

During the 60s and early 70s, practitioners of operations research and systems engineering attempted to transfer their approaches into the context of social systems. It led to disasters. It was this period when "social engineering" emerged as an approach to address societal problems. A recognition of failed attempts have led to changes in direction, best manifested by the quotation of Sage in the paragraph above.

3.1.4 Cybernetics

Cybernetics is concerned with the understanding of self-organization of human, artificial, and natural systems; the understanding of understanding; and its relation and relevance to other transdisciplinary approaches. Cybernetics, as part of the systems movement, evolved through two phases: first-order cybernetics, the cybernetics of the observed system, and second-order cybernetics, the cybernetics of the observing system.

3.1.4.1. First-Order Cybernetics. This early formulation of cybernetics inquiry was concerned with communication and control *in* the animal and the machine (Wiener, 1948). The emphasis on the *in* allowed focus on the process of self-organization and self-regulation, on circular causal feedback mechanisms, together with the systemic principles that underlie them. These principles underlay the computer/cognitive sciences and are credited with being at the heart of neural network approaches in computing. The first-order view treated information as a quantity, as "bits" to be transmitted from one place to the other. It focused on "noise" that interfered with smooth transmission (Weatley, 1992). The content, the meaning, and the purpose of information was ignored (Gleick, 1987).

3.1.4.2. Second-Order Cybernetics. As a concept, this expression was coined by Foerster (1984), who describes this shift as follows: "We are now in the possession of the truism that a description (of the universe) implies one who describes (observes it). What we need now is a description of the 'describer' or, in other words, we need a theory of the observer" (p. 258). The general notion of second-order cybernetics is that "observing systems" awaken the notion of language, culture, and communication (Brier, 1992); and the context, the content, the meaning, and purpose of information becomes central. Second-order cybernetics, through the concept of self-reference, wants to explore the meaning of cognition and communication within the natural and social sciences, the humanities, and information science; and in such social practices as design, education, organization, art, management, and politics, etc. (p. 2).

3.1.5 The Continuing Evolution of Systems Inquiry

The first part of this chapter describes the emergence of the systems idea and its manifestation in the three branches of systems inquiry: systems theory, systems philosophy, and systems methodology. This section traces the evolution of systems inquiry. This evolutionary discussion will be continued later in a separate section by focusing on "human systems inquiry."

3.1.5.1. The Continuing Evolution of Systems Thinking. In a comprehensive report, commissioned by the Society of General Systems Research, Cavallo (1979) says that systems inquiry shattered the essential features of the traditional scientific paradigm characterized by analytic thinking, reductionism, and determinism. The systems paradigm articulates synthetic thinking, emergence, communication and control, expansionism, and teleology. The emergence of these core systems ideas was the consequence of a change of focus, away from entities that cannot be taken apart without loss of their essential characteristics, and hence can not be truly understood from analysis.

First, this change of focus gave rise to synthetic or systems thinking as complementary to analysis. In synthetic thinking an entity to be understood is conceptualized not as a whole to be taken apart but as a part of one or more larger wholes. The entity is explained in terms of its function, and its role in its larger context. Second, another major consequence of the new thinking is expansionism (an alternative to reductionism), which asserts that ultimate understanding is an ideal that can never be attained but can be continuously approached. Progress towards it depends on understanding ever-larger and more inclusive wholes. Third, the idea of nondeterministic causality, developed by Singer (1959), made it possible to develop the notion of objective teleology, a conceptual system in which such teleological concepts as free will, choice, function, and purpose could be operationally defined and incorporated into the domain of science.

3.1.5.2. A General Theory of Dynamic Systems. The theory was developed by Jantsch (1980). He argues that an emphasis on structure and dynamic equilibrium (steadystate flow), which characterized the earlier development of general systems theory, led to a profound understanding of how primarily technological structures may be stabilized and maintained by complex mechanisms that respond to negative feedback. (Negative feedback indicates deviation from established norms and calls for a reduction of such deviation.) In biological and social systems, however, negative feedback is complemented by positive feedback, which increases deviation by the development of new systems processes and forms. The new understanding that has emerged recognizes such phenomena as self-organization, self-reference, self-regulation, coherent behavior over time with structural change, individuality, symbiosis, and coevolution with the environment, and morphogenesis.

This new understanding of systems behavior, says Jantsch, emphasizes process in contrast to "solid" subsystems structures and components. The interplay of process in systems leads to evolution of structures. An emphasis is placed on "becoming," a decisive conceptual breakthrough brought about by Prigogine (1980). Prigogine's theoretical development and empirical conformation of the so-called *dissipative structures* and his discovery of a new ordering systems principle called *order through fluctuation* led to an explication of a "general theory of dynamic systems."

During the early 80s, a whole range of systems thinking— based methodologies emerged, based on what is called *soft-systems thinking.* These are all relevant to human and social systems and will be discussed under the heading of human systems inquiry. In this section, two additional developments are discussed: systems thinking based on "liberating systems theory" and "unbounded systems thinking."

3.1.5.3. Liberating Systems Theory (Flood, pp. 210—211, 1990). This theory is (1) in pursuit of freeing systems theory from certain tendencies and, in a more general sense, (2) tasking systems theory with liberation of the human condition. The first task is developed in three trends: (1) the liberation of systems theory generally from the natural tendency toward self-imposed insularity, (2) the liberation of systems concepts from objectivist and subjectivist delusions, and (3) the liberation of systems theory specifically in cases of internalized localized subjugations in discourse and by considering histories and progressions of systems thinking. The second task of the theory focuses on liberation and emancipation in response to domination and subjugation in work and social situations.

***3.1.5.5.* Unbounded Systems Thinking (Mitroff & Linstone, 1993).** This development "is the basis for the 'new thinking' called for in the information age" (p. 91). In unbounded systems thinking (UST), "everything interacts with everything."

> All branches of inquiry depend fundamentally on one another. The widest possible array of disciplines, professions, and branches of knowledge—capturing distinctly different paradigms of thought—must be consciously brought to bear on our problems. In UST, the traditional hierarchical ordering of the sciences and the professions—as well as the pejorative bifurcation of the sciences into 'hard' vs. 'soft'—is replaced by a circular concept of relationship between them. The basis for choosing a particular way of modeling or representing a problem is not governed merely by considerations of conventional logic and rationality. It may also involve considerations of justice and fairness as perceived by various social groups and by consideration of personal ethics or morality as perceived by distinct persons" (p. 9).

***3.1.5.6.* Living Systems Theory.** This theory was developed by Miller (1978) as a continuation and elaboration of the organismic orientation of Bertalanffy. The theory is a conceptual scheme for the description and analysis of concrete identifiable living systems. It describes seven levels of living systems, ranging from the lower levels of cell, organ, and organism, to higher levels of group, organizations, societies, and supranational systems.

The central thesis of living systems theory is that at each level a system is characterized by the same 20 critical subsystems whose processes are essential to life. A set of these subsystems processes information (input transducer, internal transducer, channel and net, decoder, associator, decider, memory, encoder, output transducer, and time). Another set processes matter and energy (ingestor, distributor, converter, producer, storage, extruder, motor, and supporter). Two subsystems (reproducer and boundary) process matter/ energy and information.

Living system theory presents a common framework for analyzing structure and process and identifying the health and well-being of systems at various levels of complexity. A set of cross-level hypotheses was identified by Miller as a basis for conducting such analysis. During the 80s, Living systems theory has been applied by a method—called living systems process analysis—to the study of complex problem situations embedded in a diversity of fields and activities. [Living systems process analysis has been applied in educational contexts by Banathy and Mills (1988).]

3.1.6 Human Systems Inquiry

Human systems inquiry focuses systems theory, systems philosophy, and systems methodology and their applications on social or human systems. This section portrays human systems inquiry as follows: (I) present some of its basic characteristics, (2) describe the various types of human or social systems, (3) discuss the nature of problem situations and solutions in human systems inquiry, and (4) introduce the "soft-systems" approach and social systems design. The discussion of these issues will help us appreciate why human systems inquiry must be different from other modes of inquiry. Furthermore, inasmuch as education is a human system, such understanding and a review of approaches to human systems inquiry will lead to our discussion on systems inquiry in education.

3.1.6.1. The Characteristics of Human Systems. *Human Systems Are Different* is the title of the last book of the systems philosopher Geoffrey Vickers (1983). Discussing the characteristics of human systems, he provides a summary of their open nature as follows. (1) Open systems are nests of relations that are sustained through time. They are sustained by these relations and by the process of regulation. The limits within which they can be sustained are the conditions of their stability. (2) Open systems depend on and contribute to their environment. They are dependent on this interaction as well as on their internal interaction. These interactions/dependencies impose constraints on all their constituents. Human systems can mitigate but cannot remove these constraints, which tend to become more demanding and at times even contradictory as the scale of the organization increases. This might place a limit on the potential of the organization. (3) Open systems are wholes, but are also parts of larger systems, and their constituents may also be constituents of other systems.

Change in human systems is inevitable. Systems adapt to environmental changes, and in a changing environment this becomes a continuous process. At times, however, adaptation does not suffice, so the whole system might change. Through coevolution and cocreation, change between the systems and its environment is a mutual recursive phenomenon (Buckley, 1968; Jantch, 1976, 1980). Wheatley (1992), discussing stability, change, and renewal in self-organizing system, remarks that in the past, scientists focused on the overall structure of systems, leading them away from understanding the processes of change that makes a system viable over time. They were looking for stability. Regulatory (negative) feedback was a way to ensure the stability of systems, to preserve their current state. They overlooked the function of positive feedback that moves the system toward change and renewal.

Checkland (1981) presents a comprehensive characterization of what he calls *human activity systems* (HASs). HASs are very different from natural and engineered systems. Natural and engineered systems cannot be other than what they are.

> Human activity systems, on the other hand, are manifested through the perception of human beings who are free to attribute meanings to what they perceive. There will never be a single (testable) account of human activity systems, only a set of possible accounts, all valid according to particular *Weltanshaungen* (p. 14).

He further says, that HASs are structured sets of people who make up the system, coupled with a collection of such activities as processing information, making plans, performing, and monitoring performance.

According to Argyris and Schon (1979), a social group becomes an organization when members devise procedures for "Making decisions in the name of the collectivity, delegating to individuals the authority to act for the collectivity, and setting boundaries between the collectivity and the rest of the world" (p. 13). Ackoff and Emery (1972) characterize human systems as purposeful systems whose members are also purposeful individuals who intentionally and collectively formulate objectives. In human systems, "the state of the part can be determined only in reference to the state of the system. The effect of change in one part or another is mediated by changes in the state of the whole" (p. 218).

Ackoff (1981) suggests that human systems are purposeful systems that have purposeful parts and are parts of larger purposeful systems. This observation reveals three fundamental issues, namely, how to design and manage human systems so that they can effectively and efficiently serve (1) their own purposes, (2) the purposes of their purposeful parts and people in the system, and (3) the purposes of the larger system(s) of which they are part. These functions are called: (1) self-directiveness, (2) humanization, and (3) environmentalization, respectively.

Viewing human systems from an evolutionary perspective, Jantsch (1980) suggests that according to the dualistic paradigm, adaptation is a response to something that evolved outside of the systems. He notes, however, that with the emergence of the self-organizing paradigm, a scientifically founded nondualistic view became possible. This view is process oriented and establishes that evolution is an integral part of self-organization. True self-organization incorporates self-transcendence, the creative reaching out of a human system beyond its boundaries. Jantsch concludes that creation is the core of evolution, it is the joy of life, it is not just adaptation, not just securing survival. In the final analysis, says Laszlo (1987), social systems are value-guided systems. Insofar as they are independent of biological need-fulfillment and reproductive needs, cultures satisfy not body needs but values. All cultures respond to such suprabiological values. But in what form they do so depends on the specific kind of values people happen to have.

3.1.6.7. Types of Human Systems. Human activity systems (HASs), such as educational systems, are purposeful creations. People in these systems select, organize, and carry out activities in order to attain their purposes. Reviewing the research of Ackoff (1981), Jantsch (1976), Jackson and Keys (1984), and Southerland (1973), the author developed a comprehensive classification of HASs (1988) based on: (1) the degree to which they are open or closed, (2) their mechanistic vs. systemic nature, (3) their unitary vs. pluralistic position on defining their purpose, and (4) the degree and nature of their complexity (simple, detailed, dynamic). Based on these dimensions, we can differentiate five types of HASs: rigidly controlled, deterministic, purposive, heuristic, and purpose seeking.

3.1.6.2.1. Rigidly Controlled Systems. These systems are rather closed. Their structure is simple, consisting of few elements with limited interaction among them. They have a singleness of purpose and clearly defined goals, and act mechanically. Operational ways and means are prescribed. There is little room for self-direction. They have a rigid structure and stable relationship among system components. Examples are assembly-line systems and manmachine systems.

3.1.6.3.2. Deterministic Systems. These are still more closed than open. They have clearly assigned goals; thus, they are unitary. People in the system have a limited degree of freedom in selecting methods. Their complexity ranges from simple to detailed. Examples are bureaucracies, instructional systems, and national educational .

3.1.6.3.3. Purposive Systems. These are still unitary but are more open than closed, and react to their environment in order to maintain their viability. Their purpose is established at the top, but people in the system have freedom to select operational means and methods. They have detailed to dynamic complexity. Examples are corporations, social service agencies, and our public education systems.

3.1.6.3.4. Heuristic Systems. Such systems as R&D agencies and innovative business ventures formulate their own goals under broad policy guidelines; thus, they are somewhat pluralistic. They are open to changes and often initiate changes. Their complexity is dynamic, and their internal arrangements and operations are systemic. Examples of heuristic systems include innovative business ventures, educational R&D agencies, and alternative educational systems.

3.1.6.3.5. Purpose-Seeking Systems. These systems are ideal seeking and are guided by their vision of the future. They are open and coevolve with their environment. They exhibit dynamic complexity and systemic behavior. They are pluralistic, as they constantly seek new purposes and search for new niches in their environments. Examples are (a) communities seeking to establish integration of their systems of leaming and human development with social, human, and health service agencies, and their community and economic development programs, and (b) cutting-edge R&D agencies.

In working with human systems, the understanding of what type of system we are working with, or the determination of the type of systems we wish to design, is crucial in that it suggests the selection of the approach and the methods and tools that are appropriate to systems inquiry.

3.1.7 The Nature of Problem Situations and Solutions

Working with human systems, we are confronted with problem situations that comprise a system of problems rather than a collection of problems. Problems are embedded in uncertainty and require subjective interpretation. Churchman (1971) suggested that in working with human systems, subjectivity cannot be avoided. What really matters, he says, is that systems are unique, and the task is to account for their uniqueness; and this uniqueness has to be considered in their description and design. Our main tool in working with human systems is subjectivity: reflection on the sources of knowledge, social practice, community, and interest in and commitment to ideas, especially the moral idea, affectivity, and faith.

Worklng with human systems, we must recognize that they are unbounded. Factors assumed to be part of a problem are inseparably linked to many other factors. A technical problem in transportation, such as the building of a freeway, becomes a land-use problem, linked with economic, environmental, conservation, ethical, and political issues. Can we really draw a boundary? When we seek to improve a situation, particularly if it is a public one, we find ourselves facing not a problem but a cluster of problems, often called *problematique.* Peccei (1977), the founder of the Club of Rome, says that:

> Within the problematique, it is difficult to pinpoint individual problems and propose individual solutions. Each problem is related to every other problem; each apparent solution to a problem may aggravate or interfere with others; and none of these problems or their combination can be tackled using the linear or sequential methods of the past" (p. 61).

Ackoff suggests (1981) that a set of interdependent problems constitutes a system of problems, which he calls a *mess.* Like any system, the mess has properties that none of its parts has. These properties are lost when the system is taken apart. In addition, each part of a system has properties that are lost when it is considered separately. The solution to a mess depends on how its parts interact. In an earlier statement, Ackoff (1974) says that the era of "quest for certainty" has passed. We live an age of uncertainty in which systems are open, dynamic; in which problems live in a moving process. "Problems and solutions are in constant flux, hence problems do not stay solved. Solutions to problems become obsolete even if the problems to which they are addressed are not" (p. 31). Ulrich (1983) suggests that when working with human systems, we should reflect critically on problems. He asks: How can we produce solutions if the problems remain unquestioned? We should transcend problems as originally stated and should explore critically the problem itself with all of those who are affected by the problem. We must differentiate well-structured and well-defined problems in which the initial conditions, the goals, and the necessary operations can all be specified, from ill-defined or ill-structured problems, the kind in which initial conditions, the goals, and the allowable operations cannot be extrapolated from the problem. Discussing this issue, Rittel and Webber (1974) suggest that science and engineering are dealing with well-structured or tame problems. But this stance is not applicable to open social systems. Still, many social science professionals have mimicked the cognitive style of scientists and the operational style of engineers. But social problems are inherently wicked problems. Thus, every solution of a wicked problem is tentative and incomplete, and it changes as we move toward the solution. As the solution changes, as it is elaborated, so does our understanding of the problem. Considering this issue in the context of systems design, Rittel suggests that the "ill-behaved" nature of design problem situations frustrates all attempts to start out with an information and analysis phase, at the end of which a clear definition of the problem is rendered and objectives are defined that become the basis for synthesis, during which a "monastic" solution can be worked out. Systems design requires a continuous interaction between the initial phase that triggers design and the state when design is completed.

3.1.8 The Soft-Systems Approach and Systems Design From the 70s on, it was generally realized that the nature of issues in human/social systems is "soft" in contrast with "hard" issues and problems in systems engineering and other quantitative focused systems inquiry.

> Hard-systems thinking and approaches were not usable in the context of human activity systems. "It is impossible to start the studies by naming 'the system' and defining its objectives, and without this naming/definition, hard systems thinking collapses" (Checkland, 1981; Checkland and Scholes, 1990).

Churchman in his various works (1968a, 1968b, 1971, 1979, 1981) has been the most articulate and most effective advocate of ethical systems theory and morality in human systems inquiry. Human systems inquiry, Churchman says, has to be value oriented, and it must be guided by the social imperative, which dictates that technological efficiency must be subordinated to social efficiency. He speaks for a science of values and the development of methods by which to verify ethical judgments. He took issue (Churchman, 1971) with the design approach where the focus is on various segments of the system. When the designer detects a problem in a part, he moves to modify it. This approach is based on the separability principle of incrementalism. He advocates "nonseperabilty" when the application of decision rules depends on the state of the whole system, and when a certain degree of instability of a part occurs, the designer can recognize this event and change the system so that the part becomes stable. "It can be seen that design, properly viewed, is an enormous liberation of the intellectual spirit, for it challenges this spirit to an unbounded speculation about possibilities" (p. 13). A liberated designer will look at present practice as a point of departure at best. Design is a thought process and a communication process. Successful design is one that enables someone to transfer thought into action or into another design.

Checkland (1981) and Checkland and Scholes (1990) developed a methodology based on soft-systems thinking for working with human activity systems. They consider the methodology as:

> a learning system which uses systems ideas to formulate basic mental acts of four kinds: perceiving, predicating, comparing, and deciding for action. The output of the methodology is very different from the output of systems engineering: It is learning which leads to decision to take certain actions, knowing that this will lead not to "the problem" being now "solved," but to a changed situation and new learning" (1981, p. 17).

The methodology defined here is a direct consequence of the concept, human activity system. We attribute meaning to all human activity. Our attributions are meaningful in terms of our particular image of the world, which, in general, we take for granted.

Systems design, in the context of social systems, is a future-creative disciplined inquiry. People engage in this inquiry to design a system that realizes their vision of the future, their own expectations, and the expectations of their environment. Systems design is a relatively new intellectual technology. It emerged only recently as a manifestation of open-system thinking and corresponding ethically based soft-systems approaches. This new intellectual technology emerged, just in time, as a disciplined inquiry that enables us to align our social systems with the new realities of the information/knowledge age (Banathy, 1991).

Early pioneers of social systems design include: Simon (1969), Jones (1970), Churchman (1968, 1971, 1978), Jantsch (1976, 1980), Warfield (1976), and Sage (1977). The watershed year of comprehensive statements on systems design was 1981, marked by the works of Ackoff, Checkland, and Nadler. Then came the work of Argyris (1982), Ulrich (1983), Cross (1984), Morgan (1986), Senge (1990), Warfield (1990), Nadler and Hibino (1990), Checkland and Scholes (1990), Banathy (1991), Hammer and Champy (1993), and Mitroff and Linstone (1993).

Prior to the emergence of social systems design, the improvement approach to systems change manifested traditional social planning (Banathy, 1991). This approach, still practiced today, reduces the problem to manageable pieces and seeks solutions to each. Users of this approach believe that solving the problem piece by piece ultimately will correct the larger issue it aims to remedy. But systems designers know that "getting rid of what is not wanted does not give you what is desired." In sharp contrast with traditional social planning, systems design—represented by the authors above—seeks to understand the problem situation as a system of interdependent and interacting problems, and seeks to create a design as a system of interdependent and interacting solution ideas. Systems designers envision the entity to be designed as a whole, as one that is designed from the synthesis of the interaction of its parts. Systems design requires both coordination and integration. We need to design all parts of the system interactively and simultaneously. This requires coordination, and designing for interdependency across all systems levels invites integration.

3.1.9 Reflections

In the first part of this chapter, systems inquiry was defined, and the evolution of the systems movement was reviewed. Then we focused on human systems inquiry, which is the conceptual foundation of the development of a systems view and systems applications in education. As we reflect on the ideas presented in this part, we realize how little of what was discussed here has any serious minifestation or application for education. Therefore, the second part of this chapter is devoted to the exploration of a systems view of education and its practical applications in working with systems of learning and human development.

3.2 PART TWO: THE SYSTEMS VIEW AND ITS APPLICATION IN EDUCATION

In the first section of this part of the chapter is **a** discussion of the systems view and its relevance to education. This is followed by a focus on the application of the intellectual technology of comprehensive systems design as an approach to the transformation of education.

3.2.1 A Systems View of Education

For any system of interest, a systems view enables us to explore and characterize the system of our interest, its environment, and its components and parts. We can acquire a systems view by integrating systems concepts and principles in our thinking and learning to use them in representing our world and our experiences with their use. A systems view empowers us to think of ourselves, the environments that surround us, and the groups and organizations in which we live in a new way: the systems way. This new way of thinking and experiencing enables us to understand and describe the following:

- Characteristics of the "embeddedness" of educational systems operating at several interconnected levels (e.g., institutional, administrational, instructional, learning experience levels)
- Relationships, interactions, and mutual interdependencies of systems operating at those levels
- Purposes, the goals, and the boundaries of educational systems
- Relationships, interactions, and information/matter/energy exchanges between our systems and their environments
- Dynamics of interactions, relationships, and patterns of connectedness among the components of systems
- Properties of wholeness and the characteristics that emerge at various systems levels as a result of systemic interaction and synthesis
- Systems processes, i.e., the behavior and change of systems and their environments over time.

The systems view generates insights into ways of knowing, thinking, and reasoning that enable us to pursue the kind of inquiry described above. Systemic educational renewal will become possible only if the educational community will develop a systems view of education, if it embraces the systems view, and if it applies the systems view in its approach to reform.

Systems inquiry and systems applications have been applied in the worlds of business and industry, in information technology, in the health services, in architecture and engineering, and in environmental issues. However, in education—except for a narrow application in instructional technology (discussed later) — systems inquiry is highly underconceptualized and underutilized, and it is often manifested in misdirected applications.

With very few exceptions, systems philosophy, systems theory, and systems methodology as subjects of study and applications are not yet on the agenda of our educational professional development programs. And, as a rule, capability in systems inquiry is not yet in the inventory of our educational research community. It is my firm belief that unless our educational communities and our educational professional organizations embrace systems inquiry, and unless our research agencies learn to pursue systems inquiry, the notions of "systemic" reform and "systemic approaches" to educational renewal will remain hollow and meaningless buzzwords.

The notion of systems inquiry enfolds large sets of concepts that constitute principles, common to all kinds of systems. Acquiring a "systems view of education" means that we learn to think about education as a system, we can understand and describe it as a system, we can put the systems view into practice and apply it in educational inquiry, and we can design education so that it will manifest systemic behavior. Once we individually and collectively develop a systems view, then—and only then—can we become "systemic" in our approach to educational reform, only then can we apply the systems view to the reconceptualization and redefinition of education as a system, and only then can we engage in the design of systems that will nurture learning and enable the full development of human potential.

During the past decade, we have applied systems thinking and the systems view in human and social systems. As a result we now have a range of systems models and methods that enable us to work creatively and successfully with education as a complex social system. We have organized these models and methods in four complementary domains of organizational inquiry (Banathy, 1988) as follows:

- The systems analysis and description of educational systems by the application of three systems models:

  the systems environment, functions/structure, and process/behavioral models

- Systems design, conducting comprehensive design inquiry with the use of design models, methods, and tools appropriate to education

- Implementation of the design by systems development and institutionalization

- Systems management and the management of change

Figure 3-1 depicts the relational arrangement of the four domains of organizational inquiry. In the center of the figure is the integrating cluster.

In the center, the core values, core ideas, and organizing perspectives constitute bases for both the development of the inquiry approach and the decisions we make in the course of the inquiry.

Of special interest to us in this chapter is the description and analysis of educational systems and comprehensive systems design as a disciplined inquiry that offers potential for the development of truly systemic educational reform. In the rest of the chapter, we focus on these two aspects of systems inquiry.

3.2.2 Three Models That Portray Education as a System

Models are useful as **a** frame of reference to talk about the system the models represent. Because our purpose here is to understand and portray education as a system, it is important to create a common frame of reference for our discourse, to build systems models of education.

Models of social systems are built by the relational organization of the concepts and principles that represent the context, the content, and the process of social systems. I constructed three models (Banathy, 1992) that represent (a) systems-environment relationships, (b) the functions/structure of social systems, and (c) the processes and behavior of systems through time. These models are "lenses" that can be used to look at educational systems and understand, describe, and analyze them as open, dynamic, and complex social systems. These models are briefly described next.

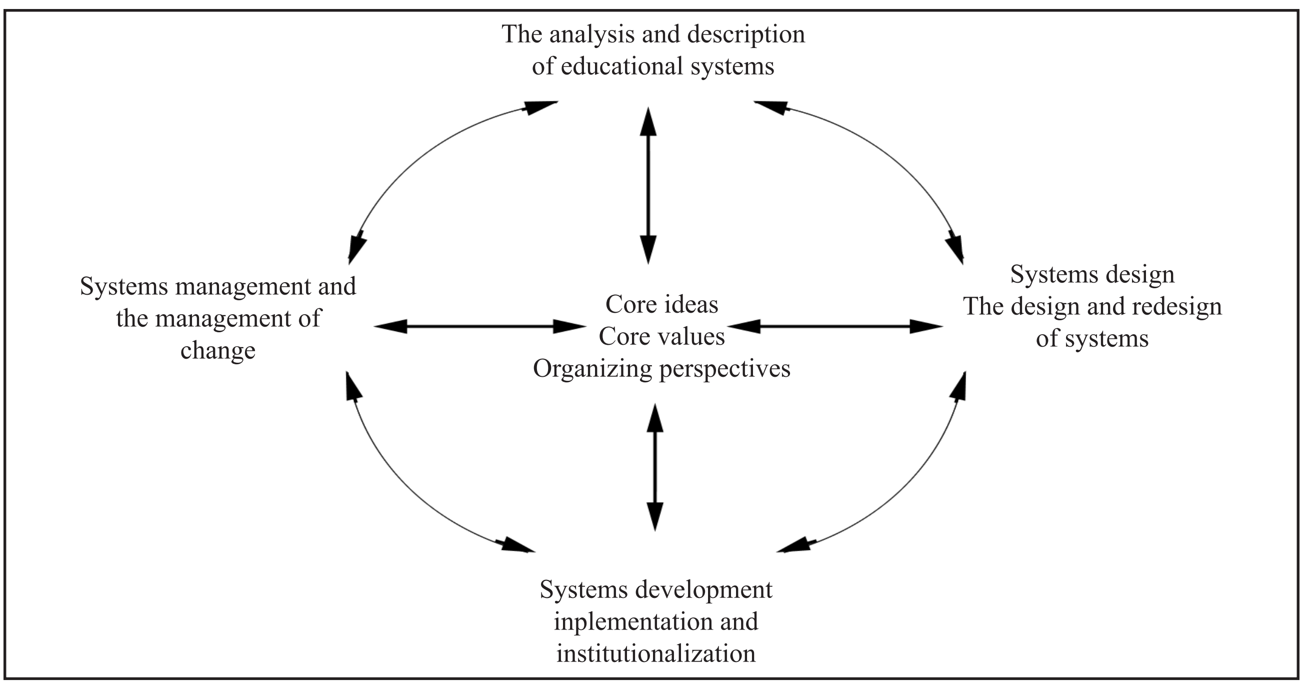

Figure 3-1. A comprehensive system of educational inquiry.

3.2.2.1. Systems-Environment Model. The use of the systems-environment model enables us to describe an educational system in the context of its community and the larger society. The concepts and principles that are pertinent to this model help us define systems-environment relationships, interactions, and mutual interdependencies. A set of inquiries, built into the model, guide the user to make an assessment of the environmental responsiveness of the system and, conversely, the adequacy of the responsiveness of the environment toward the system.

3.2.2.2. Functions/Structure Model. The use of the functions/structure model focuses our attention on what the educational system *is* at a given moment of time. It projects a still-picture" image of the system. It enables us to (a) describe the goals of the system (that elaborate the purposes that emerged from the systems-environment model), (b) identify the functions that have to be carried out to attain the goals, (c) select the components (of the system) that have the capability to carry out the functions, and (d) formulate the relational arrangements of the components that constitute the structure of the system. A set of inquiries are built into the model that guide the user to probe into the function/structure adequacy of the system.

3.2.2.3. Process/Behavioral Model. The use of the process/behavioral model helps us to concentrate our inquiry on what the educational system *does* through time. It projects a 'motion-picture" image of the system and guides us in understanding how the system behaves as a changing and living social system; how it (a) receives, screens, assesses, and processes input; (b) transforms input for use in the system; (c) engages in transformation operations by which to produce the expected output; (d) guides the transformation operations; (e) processes the output and assesses its adequacy; and (f) makes adjustment in the system if needed or imitates the redesign of the system if indicated. The model incorporates a set of inquiries that guides the user to evaluate the systems from a process perspective.

What is important for us to understand is that no single model can provide us with a true representation of an educational system. Only if we consider the three models jointly can we capture a comprehensive image of education as a social system.

3.2.3 Designing Social Systems

> Systems design in the context of human activity systems is a future-creating disciplined inquiry. People engage in design in order to devise and implement a new system, based on their vision of what that system should be.

There is a growing awareness that most of our systems are out of sync with the new realities of the current era. Those who understand this and are willing to face these realities call for the rethinking and redesign of our systems. Once we understand the significance of these new realities and their implications for us individually and collectively, we will reaffirm that systems design is the only viable approach to working with and creating and recreating our systems in a changing world of new realities. These new realties and the societal and organizational characteristics of the current era call for the development of new thinking, new perspectives, new insight, and—based on these—the design of systems that will be in sync with those realities and emerged characteristics.

In times of accelerating and dynamic changes, when a new stage is unfolding in societal evolution, inquiry should not focus on the improvement of our existing systems. Such a focus limits perception to adjusting or modifying the old design in which our systems are still rooted. A design rooted in an outdated image is useless. We must break the old frame of thinking and reframe it. We should transcend the boundaries of our existing system, explore change and renewal from the larger vistas of our transforming society, envision a new image of our systems, create a new design based on the image, and transform our systems by implementing the new design.

3.2.3.1. Systems Design: A New Intellectual Technology. Systems design in the context of social systems is a relatively new intellectual technology. It emerged only recently as a manifestation of open-systems thinking and corresponding soft-systems approaches. This new intellectual technology emerged, just in time, as a disciplined inquiry that enables us to align our societal systems, most specifically our educational systems, with the "new realities" of the information/knowledge age.

3.2.4 When Should We Design?

Social systems are created for attaining purposes that are shared by those who are in the system. Activities in which people in the system are engaged are guided by those purposes. There are times when there is a discrepancy between what our system actually attains and what we designated as the desired outcome of the system. Once we sense such discrepancy, we realize that something has gone wrong, and we need to make some changes either in the activities or in the way we carry out activities. The focus is changes within the system. Changes within the system are accomplished by adjustment, modification, or improvement.

But there are times when we have evidence that changes within the system would not suffice. We might realize that our purposes are not viable anymore and we need to change them. We realize that we now need to change the whole system. We need a different system; we need to redesign our system; or we need to design a new system.

The changes described above are guided by self-regulation, accomplished, as noted earlier, by positive feedback that signals the need for changing the whole system. We are to formulate new purposes, introduce new functions, new components, and new arrangements of the components. It is by such self-organization that the system responds to positive feedback and learns to coevolve with its environment by transforming itself into a new state. The process by which this self-organization, coevolution, and transformation comes about is systems design.

3.2.5. Research Findings on the Nature of Design Activity

In Cross's compendium (1984), design researchers report their findings on the general nature of design, I briefly review their findings as follows.

3.2.5.1. Darke (1984). He has found that contemporary designers have rejected the earlier "systematic, objective, analysis-synthesis approach" to design and replaced it with what Hiller et al. (1972) called *conjecture-analysis.* The point of departure of this approach is not a detailed analysis of the situation but the formulation of a conjecture that Darke has termed *primary generator* The primary generator is formed early in the design process as initiating concepts. (We later called this a system of core ideas: the first image of the system.) This primary generator helps designers make the creative leap between the problem formulation and a solution concept, as Cross noted (1982). Broad design requirements, in combination with the primary generator, help designers arrive at an initial conjecture that can be tested against specific requirements as an interactive process. Conjectures and requirements mutually shape each other. While earlier design approaches concentrated on design morphology as a sequence of boxes bearing preset labels, Darke (1982) finds that now designers fill the boxes with their own concepts and the sources of their concepts. An understanding of the subjectivity of designing reflects the diversity of human experience, which, in turn, should reflect the diversity in approaches to design.

3.2.5.2. Akin (1984). He challenges earlier assumptions about design. As Darke did, he also takes an issue with the analysis-synthesis-evaluation sequence in design. He says this approach was at the heart of almost all normative design methods of the past. He suggests that one of the unique aspects of designing is the constant generation of new task goals and the redefinition of task constraints. "Hence analysis is part of virtually all phases of design. Similarly, synthesis or solution development occurs as early as in the first stage" (p. 205). The rigid structuring of the design process into analysis-synthesis-evaluation and the tactics implied for these compartments are unrealistic. Solutions do not emerge from an analysis of all relevant aspects of the problem. Even a few cues in the design environment can be sufficient to evoke a recombined solution in the mind of the designers. Actually, this evoking is more the norm than a rational process of assembly of parts through synthesis. Many rational models of design violate the widely used criterion of designers, namely, to find a satisfying, rather than a scientifically optimized, solution. No fixed model is complex enough to represent the real-life complexities of the design process. That is why designers select approaches that produce a solution that satisfies an acceptable number of design criteria.

3.2.5.3. Lawson (1984). He conducted a controlled experiment between scientists and designers. He discovered that scientists used processes that focused on discovering the problem structure, while designers used strategies that focused on findings solutions. For the designers, the most successful and practical way to address design problem situations is not by analyzing them in depth but by quickly proposing solutions to them. This way, they discover more about the problem as well as what is an acceptable solution to it. On the other hand, scientists analyze the problem in order to discover its patterns and its rules before proposing a solution to it. Designers seek solutions by synthesis, scientists by analysis. Accordingly, designers evolve and develop methodologies that do not depend on the completion of analysis before synthesis begins.

3.2.5.4. Thomas and Carroll. Thomas and Carroll (1984) carried out **a** broad range of studies on design that indicated **a** wide range of similarities between the behavior of designers and their approaches to design, regardless of the particular subject of design. They said that they changed their original assumption that design is a form of problem solving to the opinion that design is "a way of looking at a problem." They considered design as a dialectic interactive process among the participants of the design activity. In this process, participants elaborate a goal statement into more explicit functional requirements, and then from these they elaborate the design solution.

In reviewing the four research findings, Cross (1982, pp. 172-73) arrives at two major conclusions. The first is an inevitable emphasis on the early generation of solutions so that a better understanding of the problem can be developed. Second is that the earlier systematic procedures tend to focus on an extensive phase of problem analysis, which seems an unrealistic approach to ill-defined problems.

In discussing systems design, the difference between systematic and systemic is a recurring issue. The term *systematic* was in vogue in the 50s and the 60s. During that period, a closed systems engineering thinking dominated the scene. The term implied regularity in a methodical procedure. In design, it means following the same steps, in a linear, one-directional causation mode; it means adhering to the same prescribed design method, regardless of the subject and the specific content and context of the design situation. Designers of the 70s and 80s have learned the confining and unproductive nature of the systematic approach. Once we understood the open-system, dynamic-complexity, nonlinear, and mutually affecting nature of social systems, we developed a "systemic" approach that liberated us from the restrictive and prescriptive rigor of being systematic. Systemic relates to the dynamic interaction of parts from which the integrity of wholeness of the system emerges. Systemic also indicates uniqueness, which is the opposite of the sameness of systematic. Systemic recognizes the unique nature of each and every system. It calls for the use of methods that respect and are responsive to the uniqueness of the particular design situation, including the unique nature of the design environment.

3.2.6 Models for Building Social Systems

Until the 70s, design, as a disciplined inquiry, was primarily the domain of architecture and engineering. In social and sociotechnical systems, the nature of the inquiry was either systems analysis, operation research, or social engineering. These approaches reflected the kind of systematic, closedsystems, and hard-systems thinking discussed in the previous section. It was not until the 70s that we realized that the use of these approaches was not applicable; in fact they were counterproductive to working with social systems. We became aware that social systems are open systems; they have dynamic complexity; and they operate in turbulent and ever-changing environments. Based on this understanding, a new orientation emerged, based on "soft-systems" thinking. The insights gained from this orientation became the basis for the emergence of a new generation of designers and the development of new design models applicable to social systems. Earlier we listed systems researchers who made significant contributions to the development of approaches to the design of open social systems. Among them, three scholars — Ackoff, Checkland, and Nadler — were the ones who developed comprehensive process models of systems design. Their work did set the trend for continuing work in design research and social systems design.

3.2.6.1. Ackoff: A Model for the Design of Idealized Systems. The underlying conceptual base of Ackoff's design model (1981) is a systems view of the world. He explores how our concept of the world has changed in recent time from the machine age to the systems age. He defines and interprets the implications of the systems age and the systems view to systems design. He sets forth design strategies, followed by implementation planning. At the very center of his approach is what he calls *idealized design.*

Design commences with an understanding and assessment of what is now. Ackoff calls this process *formulating the mess.* The mess is a set of interdependent problems that emerges and is identifiable only in their interaction. thus, the design that responds to this mess "should be more than an aggregation of independently obtained solutions to the parts of the mess. It should deal with messes as wholes, systemically" (1981, p. 52). This process includes systems analysis, a detailed study of potential obstructions to development, and the creation of projections and scenarios that explore the question: What would happen if things would not change?

Having gained a systemic insight into the current state of affairs, Ackoff proceeds to the idealized design. The selection of ideals lies at the very core of the process. As he says: "It takes place through idealized design of a system that does not yet exist, or the idealized design of one that does" (p. 105). The three properties of an idealized design are: (1) It should be technologically feasible, (2) operationally viable, and (3) capable of rapid learning and development. This model is not a utopian system but "the most effective ideal-seeking system of which designers can conceive" (p. 107). The process of creating the ideal includes selecting a mission, specifying desired properties of the design, and designing the system. Ackoff emphasizes that the vision of the ideal must be a shared image. It should be created by all who are in the system and those affected by the design. Such participative design is attained by the organization of interlinked design boards that integrate representation across the various levels of the organization.

Having created the model of the idealized system, designers engage in the design of the management system that can guide the system and can learn how to learn as a system. Its three key functions are: (1) identifying threats and opportunities, (2) identifying what to do and having it done, and (3) maintaining and improving performance. The next major function is organizational design, the creation of the organization that is "ready, willing, and able to modify itself when necessary in order to make progress towards its ideals" (p. 149). the final stage is implementation planning. It is carried out by selecting or creating the means by which the specified ends can be pursued, determining what resources will be required, planning for the acquisition of resources, and defining who is doing what, when, how, and where.

3.2.6.2. Checkland's Soft-Systems Model. Checkland in his work (1981, 1992) creates a solid base for his model for systems change by reviewing (a) science as human activity, (b) the emergence of systems science, and (c) the evolution of systems thinking. He differentiates between "hard-systems thinking," which is appropriate to work with, rather than closed, engineered type of systems and "soft-systems thinking," which is required in working with social systems. He says that he is "trying to make systems thinking a conscious, generally accessible way of looking at things, not the stock of trade of experts" (p. 162). Based on soft-systems thinking, he formulated a model for working with and changing social systems.

His seven-stage model generates a total system of change functions, leading to the creation of a future system. His conceptual model of the future system is similar in nature to Ackoff's idealized system. Using Checkland's approach, during the first stage we look at the problem situation of the system, which we find in its real-life setting as being "unstructured." At this stage, our focus is not on specific problems but the situation in which we perceive the problem. Given the perceived "unstructured situation," during stage 2 we develop a richest possible structured picture of the problem situation. These first two stages operate in the context of the real world.

The next two stages are developed in the conceptual realm of systems thinking. Stage 3 involves speculating about some systems that may offer relevant solutions to the problem situation and preparing concise "root definitions" of what these systems are (not what they do). During stage 4, the task is to develop abstract representations, models of the relevant systems, for which root definitions were formulated at stage 3. These representations are conceptual models of the relevant systems, comprised of verbs, denoting functions. This stage consists of two substages. First, we describe the conceptual model. Then, we check it against a theory-based, formal model of systems. Checkland adopted Churchman's model (1971) for this purpose.

During the last three stages, we move back to the realm of the real world. During stage 5, we compare the conceptual model with the structured problem situation we formulated during stage 2. This comparison enables us to identify, during stage 6, feasible and desirable changes in the real world. Stage 7 is devoted to taking action and introducing changes in the system.

3.2.6.3. Nadler's Planning and Design Approach. Nadler, an early proponent of designing for the ideal (1967), is the third systems scholar who developed a comprehensive model (Nadler, 1981) for the design of sociotechnical systems. During phase 1, his strategy calls for the development of a hierarchy of purpose statements, which are formulated so that each higher level describes the purpose of the next lower level. From this purpose hierarchy, the designers select the specific purpose level for which to create the. system. The formulation of purpose is coupled with the identification of measures of effectiveness that indicate the successful achievement of the defined purpose. During this phase, designers explore alternative reasons and expectations that the design might accomplish.

During phase 2, "creativity is engaged as ideal solutions are generated for the selected purposes within the context of the purpose hierarchy," says Nadler (1981, p. 9). He introduced a large array of methods that remove conceptual blocks, nurture creativity, and widen the creation of alternative solutions ideas.

During phase 3, designers develop solution ideas into systems of alternative solutions. During this phase, designers play the believing game as they focus on how to make ideal solutions work, rather than on the reasons why they won't work. They try ideas out to see how they fit.

During phase 4, the solution is detailed. Designers build into the solution specific arrangements that might cope with potential exceptions and irregularities while protecting the desired qualities of solutions. As Nadler says: "Why discard the excellent solution that copes with 95% of the conditions because another 5% cannot directly fit into it?" (p. 11). As a result, design solutions are often flexible, multi-channeled, and pluralistic.

Phase 5 involves the implementation of the selected design solution. In the context of the purpose hierarchy, we set forth the ideal solution and plan for taking action necessary to install the solution. But we have to realize that the "most successful implemented solution is incomplete if it does not incorporate the seeds of its own improvement. An implemented solution should be treated as provisional" (p. 11). Therefore each system should have its own arrangements for continuing design and change.

In Nadler's recent book, coauthored by Hibino (1990), a set of principles are set forth that guide the work of designers. These principles can serve as guidelines that keep designers focused on seeking solutions rather than on being preoccupied by problems.

- The "uniqueness principle" suggests that whatever the apparent similarities, each problem is unique, and the design approach should respond to the unique contextual situation.
- The "purposes principle" calls for focusing on purposes and expectations rather than on problems. This focus helps us strip away nonessential aspects and prevents us from working on the wrong problem.
- The "ideal design principle" stimulates us to work back from the ideal target solution.
- The "systems principle" tells us that every design setting is part of a larger system. Understanding the systems matrix of embeddedness helps us to determine the multilevel complexities that we should incorporate into the solution model.
- The "limited information principle" points to the pitfall that too much knowing about the problem can prevent us from seeing some excellent alternative solutions.
- The "people design principle" underlines the necessity of involving in the design all those who are in the systems and who are affected by the design.
- The "betterment timeline principle" calls for the deliberate building into the design the capability and capacity for continuing betterment of the solution through time.

3.2.7 A Process Model of Social Systems Design

The three design models introduced above have been applied primarily in the corporate and business community. Their application in the public domain has been limited. Still, we can learn much from them as we seek to formulate an approach to the design of social and societal systems. In the concluding section of Part 2, we introduce a process model of social system design that has been inspired and informed by the work of Ackoff, Checkland, and Nadler, and is a generalized outline of our earlier work of designing educational systems (Banathy, 1991).

The process of design that leads us from an existing state to a desired future state is initiated by an expression of why we want to engage in design. We call this expression of want the *genesis of design.* Once we decide that we want to design something other than what we now have, we must:

- Transcend the existing state or the existing system and leave it behind.
- Envision an image of the system that we wish to create.
- Design the system based on the image.
- Transform the system by developing and implementing the system based on the design.

Transcending, envisioning, designing, and transforming the system are the four major strategies of the design and development of social systems, which are briefly outlined below.

3.2.7.1. Transcending the Existing State. Whenever we have an indication that we should change the existing system or create a new system, we are confronted with the task of transcending the existing system or the existing state of affairs. We devised a framework that enables designers to accomplish this transcendence and create an option field, which they can use to draw alternative boundaries for their design inquiry and consider major solution alternatives. the framework is constructed of four dimensions: the focus of the inquiry, the scope of the inquiry, relationship with other systems, and the selection of system type. On each dimension, several options are identified that gradually extend the boundaries of the inquiry. The exploration of options leads designers to make a series of decisions that charts the design process toward the next strategy of systems design.

3.2.7.2. Envisioning: Creating the First Image. Systems design creates a description, a representation, a model of the future system. This creation is grounded in the designers' vision, ideas, and aspirations of what that future system should be. As the designers draw the boundaries of the design inquiry on the framework and make choices from among the options, they collectively form core ideas that they hold about the desired future. they articulate their shared vision and synthesize their core ideas into the first image of the system. This image becomes a magnet that pulls designers into designing the system that will bring the image to life.

3.2.7.3. Designing the New System Based on the Image. the image expresses an intent. One of the key issues in working with social systems is: How to bring intention and design together and create a system that transforms the image into reality? the image becomes the basis that initiates the strategy of transformation by design. The design solution emerges as designers: (1) formulate the mission and purposes of the future system, (2) define its specifications, (3) select the functions that have to be carried out to attain the mission and purposes, (4) organize these functions into a system, (5) design the system that will guide the functions and the organization that will carry out the functions, (6) define the environment that will have the resources to support the system, (7) describe the new system by using the three models we described earlier—the systems-environment model, the functions/structure model, and the process/behavioral model (Banathy, 1992)—and (8) prepare a development/implementation plan.

3.2.7.4. Transforming the System Based on the Design. The outcome of design is a description, a conceptual representation, or modeling of the new system. Based on the models, we can bring the design to life by developing the system based on the models that represent the design and then implementing and institutionalizing it (Banathy, 1986).

We elaborated the four strategies in the context of education in our earlier work (1991) as we described the processes of (1) transcending the existing system of education, (2) envisioning and defining the image of the desired future system, (3) designing the new system based on the image, and (4) transforming the existing system by developing/ implementing/institutionalizing the new system based on the design.

In this section, a major step has been taken toward the understanding of systems design by exploring some research findings about design, examining a set of comprehensive design models, and proposing a process model for the design of educational and other social systems. In the closing section, we present the disciplined inquiry of systems design as the new imperative in education and briefly highlight distinctions between instructional design and systems design.

3.2.8 Systems Design: The New Imperative in Education

Many of us share a realization that today's schools are far from being able to do justice to the education of future generations. There is a growing awareness that our current design of education is out of sync with the new realities of the information/knowledge era. Those who are willing to face these new realities understand that:

- Rather than improving education, we should *transcend* it.
- Rather than revising it, we should *revision* it.
- Rather then reforming, we should *transform* it by design.

We now call for a metamorphosis of education. It has become clear to many of us that educational inquiry should not focus on the improvement of existing systems. Staying within the existing boundaries of education constrains and delimits perception and locks us into prevailing practices. At best, improvement or restructuring of the existing system can attain some marginal adjustment of an educational design that is still rooted in the perceptions and practices of the 19th-century machine age.

But adjusting a design—rooted in an outdated image-creates far more problems than it solves. We have already found this out. The escalating rhetoric of educational reform has created high expectations, but the realities of improvement efforts have not delivered on those expectations. Improving what we have now does not lead to any significant results, regardless of how much money and effort we invest in it.

> Two roads diverged in a woods—and I—I took the road less traveled by, and that has made all the difference" (Robert Frost).

Our educational communities—including our Educational Technology Community—have reached a juncture in our journey toward educational-renewal. We can continue to travel on the well-known road of our past and present practices with some attention paid to improving the road, so that we can travel faster. We can even restructure the schedules, the programs of—and the responsibilities for—the journey. None of these adjustments will make much difference. Or we can take the risk of choosing the less-traveled road so that we can make a difference in the education of this nation and in the development of our society.

But taking the less-traveled road, we must transcend our old ways of thinking and develop new ways. We must reframe our mindset from problem focus to solution focus. We must unload the baggage of our past practices, and must learn new ones.

The new thinking is systems thinking; the new mindset is a systems view of education; and the new practice is the application of systems design. These are the prerequisites of a purposeful and viable creation of new organizational capacities and individual and collective capabilities that enable us to empower our educational communities so that they can engage in the design and transformation of our educational systems by creating new systems of learning and human development.

3.2.9 Instructional Design Is Not Systems Design

Some of my friends in the educational technology community continue to ask me: Is there really a difference between the intellectual technology of instructional design and systems design? My answer continues to be a definite Yes. A review of this chapter should lead the reader to an understanding of the difference.

An understanding of the process of designing education as an open social system, reviewed here, and the comparison of this with the process of designing instructional or training systems, known well to the reader, will clearly show the difference between the two design inquiries. I discussed this difference at some length earlier (1987). Here I briefly highlight some of the differences:

> Education as social system is open to its environment, its community, and the larger society, and it constantly and dynamically interacts with its environment,
>
> An instructional system is a subsystem of an instructional program that delivers a segment of the curriculum, The curriculum is embedded in the educational system.
>
> An instructional system is three systems levels below education as a social system.
>
> We design an educational system in view of societal realities/expectations/aspirations and core ideas and values.
>
> It is from these that an image of the future system emerges, based on which we then formulate the core definition, the mission, and purposes of the system.
>
> We design an instructional system against clearly defined instructional objectives that are derived from the larger instructional program and—at the next higher level—from the curriculum.
>
> An instructional system is a closed system. The technology of its design is an engineering (hard-system) technology. An educational system is open and is constantly coevolving with its environment. Its design applies soft-systems methods.
>
> In designing an educational system we engage in the design activity those who are serving the system, those who are served by it, and those who are affected by it.
>
> An instructional system is designed by the expert educational technologist who takes into account the characteristics of the user of the system.
>
> A designed instructional system is often delivered by computer software and other mediation. An educational system is a human/social activity system that relies primarily on human/social interaction. Some of the interactions, e.g., planning or information storing, can be aided by the use of software.

3.2.10 The Challenge of the Educational Technology Community

We as members of the educational technology community face a four-pronged challenge: (1) We should transcend the constraints and limits of the means and methods of instructional technology. We should clearly understand the difference between the design of education as a social system and instructional design. (2) We should develop open-systems thinking, acquire a systems view, and develop competence in systems design. (3) We should create programs and resources that enable our larger educational community to develop systems thinking, a systems view, and competence in systems design. (4) We should assist our communities across the nation to engage in the design and development of their systems of learning and human development. Our societal challenge is to place ourself in the service of transforming education by design and help create just systems of learning and development for future generations.

Education creates the future, and there is no more important task and no more noble calling than participating in this creation.

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* This mark means primary significance.
** This mark means primary and state of the art significance.

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