TOWARD A CONTEMPORARY THEORY OF "OPEN SYSTEMS"

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The term "systems" has come to be one of the most frequently used concepts in the fields of social and behavioral sciences today. Although many scholars have attempted to make use of the systems idea and have developed a wide variety of systems theories or models during the last decade, these concepts are still vague and social and behavioral scientists do not seem yet to have arrived at an agreement on their meaning.

This article is essentially an exploratory study aimed at identifying the "systems" concept. To serve this purpose, we attempt to review the systems literature and develop a general systems framework which could be applied to a variety of open social systems. However, the application of the systems approach to the study of organizations and management has been so popular and widespread that a large number of books and articles are being written on the subject each year. Therefore, in this study we are going to deal with the systems idea and systems theories, models or approaches only in general terms and their application to organization and management will be reserved for another study that will necessarily be a continuation of this one.

Systems Identified

The concept of "systems" has been with us for many years. There is nothing new in its meaning. The man in the street can easily identify the word as meaning "an orderly relationship among the parts and the whole." He can talk about weapon systems, hydraulic systems, and electrical systems. He can mention several different types and refer to them as physical, abstract, natural, or man-made systems (Terry, 1966 : 195).

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Roughly, then, a system may be visualized by drawing a circle and placing the elements, parts, and variables inside the circle as its components. These elements may then be connected by using rubber bands, which stretch or contract as the "forces" increase or decrease. All other factors which impinge upon the system are placed in the environment, outside the circle (Chin, 1961 : 203).

That which is new concerning systems is the manner in which the concept is now being used in the social sciences. The system models used by the biological and physical sciences were seen to be applicable to human relationships in small or large units. The social scientist, including psychologists, sociologists, anthropologists, economists, and political scientists have already started to use this idea in their work.

To emphasize the scope and significance of this approach, it is perhaps sufficient to cite illustrated examples from various fields. In the natural sciences, the concept has been widely used to comprehend planetary, chemical, nuclear, and other such phenomena. In the biological sciences, the idea has been applied frequently in the study of plant and animal life at a variety of leveis. In the field of engineering, the growth of the systems approach has been rapid. In anthropology, the key element of analysis is a cultural one. In sociology - particularly as developed by Parsons - the concept of "social systems" is of crucial importance. In political science, the works of Easton, Riggs, North, Eisenstadt, Almond and Coleman, and so forth, have taken this concept as the focal point for their analyses. The "systems" idea has also found wide aplicability in the fields of communication and decision making.

Although there are slight differences in the definiton of the term "systems" in these fields, it is possible to find that they agree on its essentials.

Johnson, Kast, and Rosenzweig (1963 : 4) have defined a system as "an organized or complex whole; an assemblage or combination of things or parts forming a complex of unitary whole." The term, as they view it, connotes plan, method, order, and arrangement.

Scott (1967 : 120), following the same pattern of thought, points out that system and the interdependency of parts are interchangeable ideas. Drawing upon the conceptualization by Henderson (1935 : 86), he adopts the definition as "the interdependence of variables."

Seiler (1967 : 4), basing his descripition upon the same source, gives the definition as "a set of objects together with the relationships between the objects and between their attributes." He continues to argue that in this basic abstract sense, everything is related - in such a way that a change in one thing produces a change in all the other parts.

The common aspects of these three definitions is their concentration an assemblage, or combination, interdependence, and relationships of parts. These may be variables, things, objects, or their attributes. It is important that the parts constitute a whoie as a result of integration, interdependence and interrelations. The emphasis is on the idea of order.

Sutton (1966 : 19 - 28) also argues that the notion of a systems implies an orderly patterning in its parts. Another more explicit definition, in terms of order, is given by Parsons and Shils (1951 : 107) :

> "The most general and fundamental property of a system is the interdependence of parts or variables. Interdependence consists in the existence of determinate relationships among the parts or variables as contrasted with randomness or variability. In other words, interdependence is **order** in the relationship among the components which enter into a system."

In this definition, as well as the one given implicitly by Seiler, the underlying concept is causation. Seiler, in a sense, sees the development of the idea of the system to be a result of a change in human quality, from finding the cause of everything in a single thing, to seeing the happenings as a result of a complex interrelation of forces. While Seiler stresses the idea of multiple causation, Parsons comes closer to the existence of a more simple and stable causal relationship among the variables. This implies his emphasis on systems equilibrium, as will be discussed later.

Although it is not reflected in his definition of the term "system," Seiler (1967 : 4) makes a statement which points out another important element :

> "A change in one of the parts has an effect on the other parts of the subunit which is of vastly greater magnitude in terms of intensity and pervasiveness than the effects of a

change in the same part of the subunit or things outside the subunit."

That to which he refers is the concept of "boundary," and that is, in fact, an argument for the existence of a boundary for every system. The interaction and interdependence of the parts is more intensive within boundaries than their interactions with the objects, or the variables, in the environment of the system, outside its confines. The boundaries of a system, however, are essentially arbitrary (Emery, 1971 : 4).

The definition given by Price (1965) comes rather close to Seiler's conceptualization of the idea of systems :

> "A system is defined conceptually as a set of elements or parts which have relationships together and which are interdependent. Interdependent means that if one part of a system is affected or stimulated all the other parts will be also. A system can be identified because there is a greater exchange of energy or information within the system than there is between parts of the system and the environment."

This interpretation draws our attention to some new elements of the concept as well as covering those previously pointed out. It includes such elements as parts, relationships between parts, and interdependency of the parts. Moreover, it tells us that the boundaries of a system can be drawn and thus be identified; that there is an exchange of energy or information within the system, and also an exchange between the system and its environment. Since we are dealing with living systems, we can deduce from this definition that in order for a system to live, survive, and grow, there must be an exchange between it and its environment, as well as that among the parts, which are within the system. A system exists within an environment and cannot be completely isolated from it. The part of the world not included within a system's boundaries constitutes the environment of the system. Environment, in Weick's (1969 : 27-29) terms, is usually enacted and equivocal. An enacted environment is one which is constituted and shaped by the parts and elements of the system. An equivocal environment is characterized by uncertainty.

When it is compared with other definitions which identify a system as interrelated and interdependent parts, the definiton by Price seems to have more the flavor of dynamism. "Exchange of energy or information" refers to a dynamic process, to a more active mode of operation. Whereas, the definiton by Parsons, for example, reflects one which is static and passive. His use of the phrase "existence of determinate relationships among the parts or variables," has a fixed structural connotation.

Two other definitons by Terry (1966 : 197) and Levy (1952 : 113) indicate very well the dynamic characteristics of social systems and support the fact that they are living, vigorous entities. Terry's definiton is "a network of procedures which are integrated and designed to carry out a major activity." Here, it is important to note his ability to see a system as an integrative network of procedures, and a purposeful entity - directional in its operation. He points out that the components are considered as a **dynamic totality** or **interaction of parts** which is more important than the components themselves.

According to Levy, "a system is an operation involving a plurality of interacting individuals whose actions are, for the most part, aimed at the goals of the system in which they are involved." Levy also seems to have emphasized the operation and interaction of elements and its goal-oriented character. However, his definition differs from the one by Terry, who in regard to the purpose of the system, talks about the ideal situation - what it should be rather that what it is. And ideally, he says that it is integrated and designed to carry out a major activity. It is supposed to be goal-oriented or directional in its operation. Levy implies both the ideal situation and the existing situation in his definition. A system has been so designed that it has some goals, and its activities are presumed to be directed toward the achievement of these goals. In practice, neither systems nor their components can be completely rational entities; hence, all activities will be aimed toward the goals of the system. However, for the system to maintain its identity and to survive, it is necessary that, for the most part, the actions of the components are directed toward the achievements of the designed goals. Otherwise, it would be nothing but chaos, or a state of confusion.

The nature of systems is characterized by the term "synergy." This term means that when all the parts and elements of a system work together, the total system produces an impact greater than the sum of all individual parts. "This total impact is the synergistic effect." (Lundgren, 1974 : 6).

Closed versus Open Systems

Systems of the physical sciences sometimes can be treated as if they are closed systems, independent of external forces. Optner (1960 : 3) defines a closed system as "one which is free of variation or disturbance." He says that one way to study such a system is through the concept of the "black box." This refers to a simple machine in the physical sciences. Certain inputs are introduced into it and cogent resultant outputs are obtained from it. These procedures are highly predictable and function within statistically predictable limits. They are invariant systems and are structured, or designed, for particular purposes. There is no disturbance from the outside. Reliability in these closed systems, which are self organizing, approaches one hundred percent. Examples are hydraulic, electrical and telephone systems, and so forth. Optner refers to such systems as "structured systems."

Because of the wide applicability of this concept, earlier formulations constructed in the social sciences tried to utilize the same model of a closed system as was used in the physical sciences. This was for the purposes of understanding social entities. The argument by Chin (1960 : 206), for example, indicates this tendency :

> "All living systems are open systems - systems in contact with their environment, with input and output across system boundaries. What then is the use of talking about a closed system? What is a closed system? It means that the system is temporarily assumed to have a leak-tight boundary - there is relatively little, if any commerce across the boundary. We know that no such system can be found in reality, but it is sometimes essential to analyze a system as if it were closed so as to examine the operation of the system as affected 'only by the conditions previously established by the environment and not changing at the time of analysis, plus the relatinoships among the internal elements of the system.' The analyst then opens the system to a new impact from the environment, again closes the system, and observes and thinks out what would happen. It is, therefore, fruitless to debate the point; both open and closed system models are useful in diagnosis."

Although Chin is aware of the fact that all living systems are open and that no closed system can exist in reality, he finds some advantages in considering such systems temporarily closed for the sake of analyses. Nevertheless, it is this very concept, together with the idea of implied equilibrium, which has long blocked the development of a realistic understanding and an explanation of the organization theory and of social systems. First, Bertalanffy (1950 : 23 - 28) then Katz and Kahn (1966 : 8 - 17), Schein (1965 : 88 - 95) and others have rebelled against the classical system models because of their implicit assumptions about the closed character of social structures. The "energetic input-output system" of Katz and Kahn is based on the open-system theory as promulgated by Bertalanffy. The authors argue that system theory is basically concerned with problems of relationship, structures, and interdependence rather than with the constant attributes of objects. Living systems are dependent upon their external environment and therefore must be conceived of as open systems.

The common characteristics of the open systems, as listed by Katz and Kahn, are briefly the following :

1. Importation of "energy" from the external environment (inputs);

2. Transformation of available "energy" (throughput);

3. Exportation of the product into the environment (outputs);

4. "The patterns of activities of the energy exchange has a cyclic character." This implies that the structure of the system is a cycle of events.

5. "To survive, open systems must move to arrest the entropic process; they must acquire negative entropy," thereby stopping disturbing elements.

6. Systems need information input in the form of a negative feedback and through a selective process (coding), in order to be able to correct deviations from the course.

7. "The importation of energy to arrest entropy operates to maintain some constancy in energy exchange so that open systems which survive are characterized by a **steady state.** A steady state is not a motionless or a true equilibrium. There is a continuous export of the product of the system, but the character of the system, the ratio of energy exchanges and the relations between parts, remains the same." The tendency toward a steady state, in its simplest form, is homeostatic, and the equilibrium which complex systems approach is often that of **quasi-stationary equilibrium.**

To cope with external forces, social systems move toward incorporating within their boundaries the external resources essential to survival. The result is the preservation of the character of the system through its growth and expansion.

8. "Often systems move in the direction of differentiation and elaboration." They move toward the "multiplication and elaboration of roles with greater specialization of functions."

9. A system can reach the same final state from differing initial conditions and by a variety of paths (the principle of equifinality suggested by von Bertalanffy in 1940).

The man-machine systems (i.e., missile system) and the nonphysical ones (i.e., engineering, administration) are referred to as "incompletely structured" or "unstructured" systems by Optner (1960 : 6 - 9), and the terms are used to describe the methods of the industrial and business world. Their properties, or elements, are said to be (a) **inputs** which are variable - there are many outside disturbances here. (b) **Outputs** are unpredictable and they are statistically unstable. (c) **Processor** is either man or man-machine. (d) The system can function with a wide range of reliability **(control).** And lastly, (e) outputs are not automatically reintroduced to improve performance **(feedback).**

Optner's list of five elements - inputs, outputs, processor, control, and feedback - are, in fact, the properties of all systems. Their description here, as for the unstructured ones, may very well be taken to be the properties of open systems because of the fact that the terms "unstructured" or "incompletely structured" are used in such a way to refer to social systems as they are understood, for example, by Katz and Kahn.

Buckley (1967 : 50 - 51) has described an open system by pointing out that when such a method is open, it means not simply that it engages in interchanges with the environment, but that this interchange is an essential factor underlying the viability of the system's reproductive ability, or continuity, and its ability to change.

Buckley has expressed the frequently used distinction between open and closed systems in terms of "entropy"; "closed systems," hence, "have often been expressed in terms of entropy - to 'run down' while open systems are 'negentropic' - tending to decrease in entropy or to elaborate structure." (Brillouin, 1949 : 554 - 568 and Schrodinger, 1945). Buckley says that the typical response of the former to an intrusion of environmental events is dependent on the nature and strength of the intrusion - a loss of organization, a change in the direction of this solution of the system, or a move to a new level of equilibrium. In contrast, the typical response of the latter to environmental intrusion is elaboration, or change of the structure, to a higher or more complex level. This is because the environmental interchange is not random, but rather selective as a result of the mapping, or coding, or information-processing capabilities inherent in open systems. These are inherently adaptive ones. As one moves up on the levels of systems, it will be seen that they become more and more open "in the sense that they become involved in a wider interchange with a greater variety of aspects of the environment, that is, are capable of mapping and responding selectively to a greater range and detail of the endless variety of the environment."

Systems Theories

While there is some agreement among scholars on the meaning of "systems," there is no single body of knowledge today which can be referred to as "systems theory." Instead, there is a wide range of theories and models which have been constructed by scholars in quite different fields, through the use of systems concepts, and which are referred to as "systems theory" or "systems model." Below we shall present some examples of these theories or models, to give an idea about their uses in defferent fields. We shall see that the idea has been utilized to explain, understand, and predict mechanical systems, living organisms, groups, organizations, industry, political courses of action, the larger society, and the world.

However, because of its importance we feel obliged to survey the ways in which the systems idea has been applied to organization and management and the contributions it has made to organizational theory in another study. Thus, the work of such social and behavioral scholars as Rice, Trist, Whyte, Parsons, Likert, Argyris, Etzioni, Blake and Mouton, Katz and Kahn, Schein, Gross, Scott, and so forth, is not going to be discussed and included within the boundaries of this article.

Stanford L. Optner :

The idea of systems has long been applied to those systems of a mechanical nature. However, more recently it has also been teristics by the design. The electronic data processing system is based on five requirements :

1. A means of getting into the central processor in order to do something (input);

2. A means of getting out of the central processor after something has been done (output);

3. A means of going about the business of doing something in a reliable, automatic way (processor);

4. A means of monitoring the processor so it will operate in a prescribed way (controls); and

5. A means of monitoring the output, thus delivering the results of an operation back into the system as input, to correct future output (feedback).

Optner visualizes the organization of a computer system as shown in Figure 1.

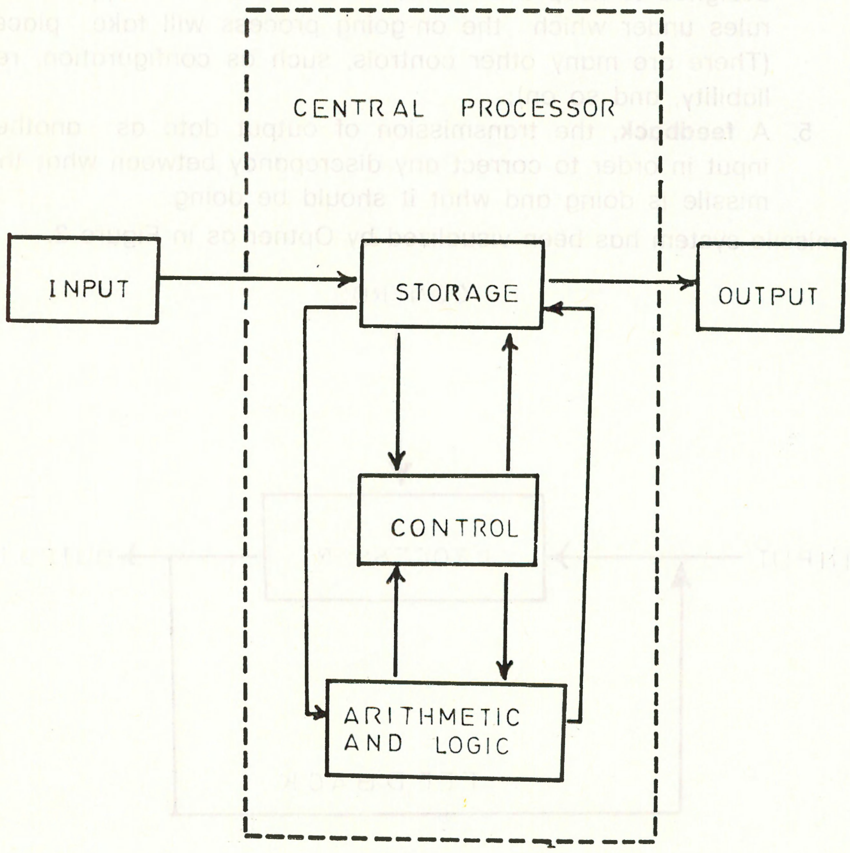

Figure 1

pertinent to computers. Optner (1960 : 9 - 10) argues that the combination of input and output peripheral equipment - with a central processor - is referred to as a computer system. He views a computer as a physical (man-machine) system. It acquires its charac-

Borrowing from a computer system. Optner applies the same elements to a missile or a weapons system. The elements of a missile in flight are given as follows :

1. A set of **inputs,** coded signals, called a program, which will tell the missile what to do;
2. A set of **outputs,** the speed and direction in which the missile is traveling, which are the results of its program;
3. A **processor,** a computer or similar device which accepts instructions, processes them, and is the operating unit on which all system elements work;
4. One or more **controls,** the built-in program that has been designed to keep the missile on its course, and applies the rules under which the on-going process will take place. (There are many other controls, such as configuration, reliability, and so on);
5. A **feedback,** the transmission of output data as another input in order to correct any discrepancy between what the missile is doing and what it should be doing.

A missile system has been visualized by Optner as in Figure 2.

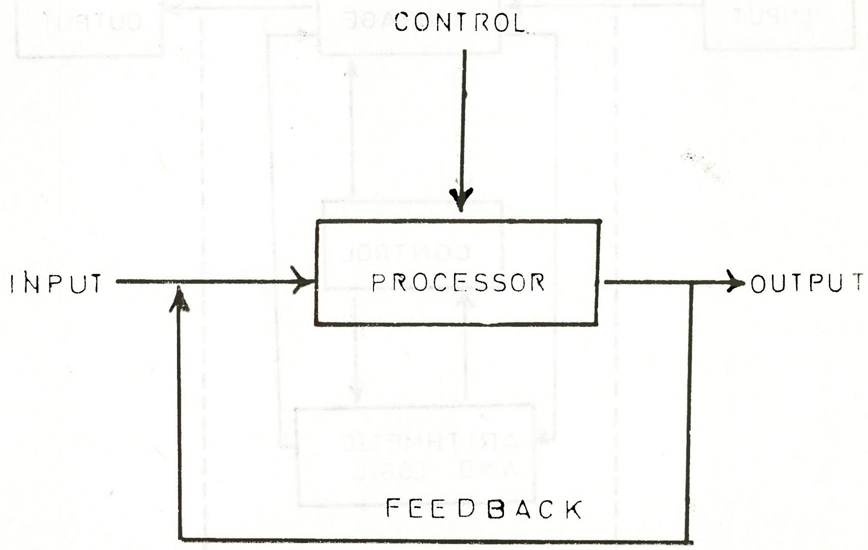

Figure 2

Ludvig von Bertalanffy :

While leading the movement toward a general systems theory, Bertalanffy in 1950, argued for a new concept which he called the "open systems theory." The basis of this theory, which is said to be a concept of the general systems theory, is that "a living organism is not a conglomeration of separate elements but a definite system possessing organization and wholeness." Bartalanffy views an organism as an open system which is influenced by, and influences its environment. Constantly, matter and energy enter it from the environment and continually change within the system. The system, thereby, maintains a state of dynamic equilibrium.

George C. Homans :

Homans' (1950) model of social systems can be applied to either the small group or the large organization. He points out that any social system exists within a three-part environment - physical, cultural, and technological. The physical one includes such factors as the terrain, climate, layout, and so on; the cultural is composed of norms, values of goals of society; and that which is technological refers to the state of knowledge and instrumentation available to the system for the performance of its task. These external conditions then specify certain activities and impose certain interactions for the individuals involved in the system which, in turn, arouse certain feelings and sentiments among individuals. Homans refers to **activities, interactions,** and **sentiments** which are determined by the environment as the "external system." All these are mutually dependent upon one another. A change in one will produce some change in others.

Homans postulated that "the higher the rate of interaction of two or more people, the more positive will be their sentiments toward each other." With increasing interaction come new sentiments, new norms and shared frames of reference which generate new activities. However, they are not necessarily specified by the external environment. Homans calls this new pattern which arises out of the external system, the "internal system" (informal organization).

These two systems are mutually dependent. Any change in either will produce some change in the other. Moreover, the two systems and the environment are mutually dependent, and have the same implication for the system change.

David Easton :

Easton (1965) applies the same concepts to a political system, which also consists of inputs and withinputs, outputs, and feedback. Inputs are variables reflecting the forces within the environment. "Withinputs" mirror the powers upon the system which arise from the inside. Inputs are classified into two broad groups - demand and support. Demands made by persons, or groups, may be external or internal to the political system, and may come from outside or inside its boundaries.

The support necessary for the maintenance of the political system arises from the same sources and is activated through its outputs. It is desirable to maintain a store of support in the event that a hostile variable is interjected into the regimen.

Outputs are transactions moving from the political system into the environment. They are in the form of "authoritative allocations of values or binding decisions and the actions implementing and related to them." (Easton, 1965 : 126).

Feedback is important because it enables the political body to respond to demands, to obtain information about the effects of the decisions made and actions taken (outputs already produced), and to know conditions within the environment, as well as within the system, to make decisions and take actions accordingly.

Almond, Coleman, and Powell (1966) have further elaborated this model of a political system as presented by Easton.

Talcott Parsons :

Parsons' (1966) interest is in social systems in general, and society in particular. To him a social system is made up of the "interaction of human individuals." Each member is both actor (having goals, ideas, attitudes, and so forth), and an object of orientation for both other actors and himself. Parsons states that any action system can be analyzed in four categaories, each referring to a problem which the system faces: (1) concern of maintenance or control of patterns of the larger system of organization, (2) integration, (3) attainment of goals relative to the environment, and (4) adaptation to the environment.

Walter Buckley :

Buckley (1967 : 8 - 9) has developed the "morphogenetic model of modern systems theory" to replace the now outmoded mechanical equilibrium and organismic models of society. Buckley is an excellent source from which to obtain an historical perspective of the evolution of systems ideas. His arguments can be summarized as follows :

With the twentieth century came rapid advances in physics, mathematics, and mechanics. A natural outcome was to view man and society as mechanical models. Man, his groups, and their interrelations were taken to cotnstitute a continuity with the rest of the mechanistically interpreted universe.

> "All were based on the interplay of natural causes, to be studied as systems of relationships that could be measured and expressed in terms of laws of social mechanics. ... Thus, we have at base the concept of 'system' of elements in mutual interrelations which may be in a state of 'equilibrium', such that any moderate change in the elements or their interrelations away from the equilibrium position are counter-balanced by changes tending to restore it."

This conception was led by Pareto and was followed by Bukharin, Sorokin, Znaniecki, and Lewin among others. It has been taken over, almost unchanged, by Homans, Parsons, and many other contemporary sociologists.

However, the concept of "equilibrium" has gone through some modifications. A given equilibrium is taken to be only a "temporary, ephemeral state" which is sometimes achieved through behavior (Mac Iver, 1964 : 172 - 173). For example, Sayles (1964 : 163) refers to it as "moving equilibrium" which means a dynamic type of stability - adjustments and readjustments to both internally generated and externally imposed pressure. But still, there is a pattern, and observably a repeating tempo - though the level may be different. Homans (1961 : 114) now used the term "practical equilibrium" to refer to the temporary state of behavior.

Buckley (1967 : 11) argues that the continued appeal to mechanical systems used to understand socio-cultural systems only postpones the search for other, more appropriate, and useful conceptualizations. The two are very different types, with basically different organizing principles and dynamics.

The **organic model** is a product of the advances in the biological sciences at the turn of the present century. Society is viewed like an organism because of the interdependence and cooperation of its parts. This outlook was advocated by Spencer. He felt that each component helped the other one for the furtherence of the whole. However, this organismic analogy was exploited to extremes by Spencer's followers as they searched for the social analogue of the heart, brain, circulatory system, and so forth.

There are, of course, pitfalls in explaining social systems through the analogy of organisms. Perhaps, the best example in expressing the difficulty in interpreting a social system (in the framework of the organic model) is to use the biological concept of **homeostasis.** An organism can change its structure very little for the purpose of adapting to change, whereas a social system has a much wider latitude (Deutsch, 1956 : 161 - 162).

The process, or adaptive model as constructed by Buckley (1967 : 18), views society as a "complex, multifaceted, fluid interplay of widely varying degrees and intensities of association and dissociation." A social system is an ongoing interactive process. It continually shifts its structure as an adaptation to internal and external conditions. "Structure" is a temporary, accommodative representation of ongoing interactive process at any time. Socio-cultural systems are inherently "structure-eleborating and changing." Process, then, focuses on the actions and interactions of the components of an ongoing system, such that varying degrees of structuring arise, persist, dissolve, or change.

The basic problem according to Buckley (1967 : 22 - 23) is "how do interacting personalities and groups define, interpret, and act on the situation?" Now a refocusing is occurring via decision theory, in terms of various ones such as "role-strain" theory, mathematical theory of games, theories of exchange, bargaining or conflicts, as well as the theories of cognitive dissonance, congruence, balance, or concept formation.

Buckley (1967 : 40) points out that in summarizing the differences between the models discussed above, the one dealing with equilibrium is applicable to types of systems which, in moving to an equilibrium point, typically lose organization and then tend to hold that minimum level within relatively narrow conditions of disturbance. Homeostatis models apply to systems tending to maintain a relatively high given level of organization against ever present tendencies to reduce it. The process, or complex adaptive system model applies to systems characterized by the elaboration or evolution of organization; they thrive on disturbances and variety in the environment.

Buckley has visualized that conceptualization with a diagram as shown in Figure 3.

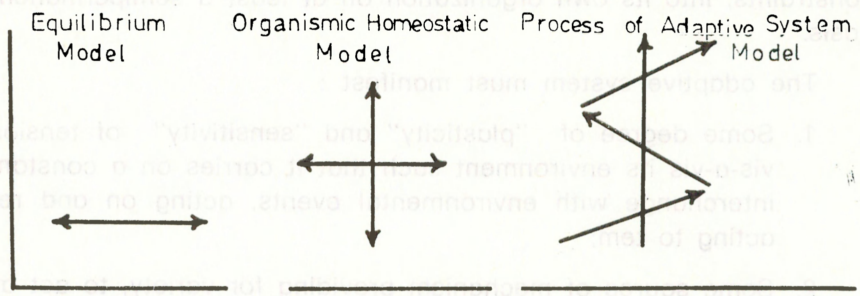

Figure 3

The charecteristics of this modern systems theory, as proposed by Buckley, can be summarized as follows. As we go upward from mechanical models to organic and socio-cultural adaptive systems: (1) the components which are interrelated become more complex in their own organization - more and more unstable - and more fundamentally alterable, by the working of the system of which they are a part; (2) the relations of parts become more flexible and the "structure" more fluid. Relationships come to depend more and more upon the transmission of information rather than energy; (3) the systems become more and more open "in the sense that they become involved in a wider interchange with a greater variety of aspects of environment, and more and more capable of mapping, or responding selectively, to a greater range and detail of endless variety of environment"; (4) system "tension" changes from occurring only occasionally, or residually, as a disturbing factor, to some level of tension as characteristic of, and vital to, such systems though it may manifest itself as now destructive, now constructive; and (5) from morphostasis (processes in complex system-environment exchanges which tend to preserve, or maintain, a system's given form, organization or state) to morphogenesis (those processes which tend to elaborate or change the system's given form, structure or state).

Buckley has developed a paradigm underlying the evolution of more and more complex adaptive systems in terms of "an abstract model of morphogenesis." This model begins with the fact of a potentially changing environment, and an adaptive system whose persistence and elaboration, to higher levels, depends upon a successful mapping of some of the environmental variety, and constraints, into its own organization on at least a semipermanent basis.[1]

The adaptive system must manifest :

1. Some degree of "plasticity" and "sensitivity" of tension vis-a-vis its environment such that it carries on a constant interchange with environmental events, acting on and re-acting to tem;
2. Some source of mechanism providing for variety, to act as a potential pool of adaptive variability to meet the problem of mapping new or more detailed variety and constraints in a changeable environment;
3. A set of selective criteria or mechanism againts which the "variety pool" may be shifted into these variations in the organization or system that more closely maps the environment and those that do not, and;
4. An arrangement for preserving and/or propagating these "successful" mappings.

General Systems Theory

Buckley's morphogenetic model of the modern system theory is based upon a hierarchical order of systems - mechanical models being at the bottom of the hierarchy and complex, adaptive ones at the top. This conceptualization brings us to the discussion of a general systems theory. Because of the fact that each system may be viewed as both a separate self-contained unit and also part of a larger one, it is quite possible to create a hierarchy of systems.

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(1) The author explains the term "mapping" as follows : "When the internal organization of an adaptive system acquires features that permit it to discriminate, act upon, and respond to aspects of the environmental variety and its constraints, we say that the system has mapped part of the environmental variety becomes selectively related to its environment." (Buckley, 1967 : 63).

By relating to each other, we can move to ever smaller subsystems and to the larger ones. At every level, however, there is an assumed system boundary within which interdependent forces are at play in intimate relationship, producing a total effect on the whole.

There has been an increasing interest in developing overall systems as frames of reference for synthesizing the results of research done on the segments of knowledge, as well as for analytical work in various areas. It has been argued that there are similarities in the theoretical construction of various disciplines, and therefore models can be developed which have applicability to many fields of study. The ultimate goal is the construction of a general systems model which could tie all disciplines together in a meaningful relationship. The fruits of the movement in that direction have been called "general systems theory" (GST).

Historically, GST developed during the early part of the twentieth century as a result of a number of parallel streams of intellectual effort emerging at the time. In particular, the need for more effective "organismic" models to account for the complexities encountered in biology, and the needs for a more effective interdisciplinary cooperation were pressing. For the first time, Bertalanffy (1962 : 1 - 10), in the 1930s and early 1940s, began to think and write in terms of extending the concept of open systems and organismic biology to a higher theoretical framework; this, as a possible means toward unification of science. The general systems theory which he was formulating was given tremendous impetus by the emerging interdisciplinary approach, and growth in the use of the systems concept in the engineering fields occasioned by the Second World War.

In 1949, a group of behavioral scientists, including Miller, Rapoport, Gerard and others, conceived the idea of an interdisciplinary approach to the problem of development and integration in their fields. Regular seminars were started in 1952, and an Institute of Behavioral Sciences was created a year later with the support given to the group by the University of Chicago.

In 1954, the Society for the Advancement of General Systems Theory was formed, and through it the Chicago group and Bertalanffy, and those associated with him were combined. In 1956, the first General Systems Yearbook was issued by the society. Boulding was the first president of the society.

Bertaianffy (1956 : 1), in his writings, has described examples of communalities that might serve to unify science. He states :

"Thus, there exists models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of 'forces' between 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. In this way we come to postulate a new discipline, called General Systems Theory. Its subject matter is the formulation and deviation of those principles which are valid for 'systems' in general."

Also writing for the first volume of **General Systems,** Boulding (1956 : 11) argues that :

"At a low level of ambition but with a high degree of confidence it (GST) seems to point out similarities in the theoretical constructions of different disciplines, where there exists, and to develop theoretical models having applicability to at least two different fields of study. At a higher level of ambition, but with perhaps a lower degree of confidence it hopes to develop something like a spectrum of theories - a system of systems which may perform the function of a 'gestalt' in theoretical construction."

Miller (1957 : 777 - 778) was interested more in developing a theory which would be more concrete and testable. He tended to exclude formulations which might exist only at the most abstract mathematical level from his "general behavior systems." He stated his understanding of the GST as follows :

"Systems are bounded regions in space-time, involving energy interchange among their parts and with their environment. GST is a series of related definitions, assumptions, and postulates about all levels of systems from atomic articles through atoms, molecules, crystals, viruses, cells, organs, individuals, small groups, societies, planets, solar systems, and galaxies."

In 1962, McClelland (1962 : 444 - 450) suggested that there was, in fact, no theory involved in GST. He states :

" 'General Systems' stands for an approach; it is a certain point of view. It might be characterized, also, as a conceptual framework within which observations of theories can be constructed. Hence it may be regarded as a working attitude useful in several branches of investigation including social research."

It is important for our purposes to emphasize McClelland's argument that "problems of modern science are those of dynamic relationships, thereby implying the existence of interactions between changing processes." This means that GST must focus on ways to handle impermanancy and change rather than on immutable laws.

GST has stimulated a large amount of theorizing, and a lesser amount of empirical research. In the study of complete systems, GST has followed two main lines or general methods. One, developed by Bertalanffy and his co-workers, "takes the world as we find it, examines the various systems that occur in it, ... and then draws up statements about the regularities that have been observed to hold." This method is essentially empirical. The second procedure, instead of studying first one system and then a second, a third, and so on, "considers the set of 'all conceivable systems' and then reduces the set to a more reassurable size." (Ashby, 1958 : 2).

Following the second method, Miller (1961 : 1 - 27) has suggested five systems levels appropriate for study of behavior, including cells, organs, individuals, face-to-face groups, and societies.

Similarly, Boulding (1956 : 14 - 17) supplied one of the early theoretical constructs for understanding the different levels at which systems exist. He suggested that there are nine such levels :

1. Frameworks - static structure;

2. Clockwork - simple dynamic systems with predetermined necessary motions;

3. Thermostats - cybernetic systems, maintaining equilibrium through self-regulation;

4. Cells - open systems, self-maintaining, first level of life;

5. Plants - genetic systems, first societal levels;

6. Animals - increased mobility, teleological behavior and self-awareness;

7. Humans - self-awareness and ability to use language and symbolism;

8. Societies - social systems of human cooperation; and

9. Transcendental systems - ultimates, absolutes, inescapables, and unknowables, but also exhibiting systematic structure and relationships.

In comparing GST with the systems theories, Bertalanffy sees GST as a basic science in its goals and interests, and in the various fields of application to which it is related. Some examples are systems engineering, operations research, and human engineering.

Another difference between GST and systems concepts is found in their respective vocabularies. Terms which are relatively common to the latter include system, boundary, environment, homeostasis-equilibrium, interaction, interdependence, structural-functional relationship, input-output, exchanges, open vs. closed system, and so forth. On the other hand, GST often tends to use such terms as analogy, structural isomorphy, formal identity, levels, subsystems, and supersytems, characteristics of organized wholes, differentiation, centralization, growth, competition, and conflict, transactionalism, self-organizing and regulating, information and communication, leading part, perspectives, and so forth. (Biller, 1964 : 4 - 8).

Boulding (1961 : 4), however, has a tendency to see the two approaches as reflective of the same movement. He states :

> "There is something abroad that might be called a systems movement of which the society for General Systems Research is merely one aspect, or perhaps merely a symptom. (The movement) is reflected in such new journals as **Management Science, Administrative Science Quarterly,** the **Journal of Operations Research,** and the **Journal of Conflict Resolution;** it is reflected in institutions like the Mental Health Research Institute at the University of Michigan, and in the RAND Corporation at Santa Monica. It is reflected in the new computer industry. It is reflected in intellectual developments such as Game Theory, Decision Theory, and the various ramifications of Operations Research."

Actually, the logic behind GST and the systems theory is almost the same. It is to look at something as an integrative whole, paying particular attention to the interrelation, as well as interaction, among the parts. However, the systems theory is closer to the operational level, while GST is more abstract. As a result of being more operational, it has generated more empirical research than GST. Both represent a point of view, an approach, a methodology, a conceptual framework, and a working attitude. Their vocabulaires overlap; both use such terms as subsystems, parts, interdependence, integration, environment, energy exchange, and so forth. Many systems theories have been developed which are based on the ideas generated by GST. For example, Katz and Kahn's "energetic input-output model" is based on Bertalanffy's conceptualization of open systems. Buckley's discussion of modern systems theory comes to be quite similar to the theoretical formulations of such general systems theorists as Boulding and Miller in regard to their argument that there is a hierarchy of systems and as one goes up this order, the complexity of systems increases.

When we consider such operations of the systems concept as defined by Dorsey (1962 : 43):

> "A bounded region in space and time, within which information and/or energy are exchanged among subsystems in greater quantities and/or at higher rates than the quantities exchanged or rates of exchange with anything outside boundary, and within which the subsystems are to some degree interdependent;"

we see that there is an agreement among the members of both movements on the definition of the term "system." This meaning is almost the same as that given by Miller and quated above. He is regarded as a general systems theorist. However, Miller can be taken to be a link between the systems theorists and those of the general systems theorists because of his emphasis on operationalization, and his tendency to exclude abstract mathematical models from his formulation.

Then the difference which is most essential between the two theories seems to be the level of generality as underlined by the term "general." Although this variance has some implications, today, there is a tendency toward combining the two movements. Examples of movements of this nature have already been given in the works of such scholars as Katz and Kahn, and Buckley. Therefore, it makes little sense today to continue making a contrast between GST and systems theories. On the contrary, efforts should be directed to their common use, thereby benefiting scientific advancement.

Other terms which are sometimes used to refer to the common meaning of GST and the systems theory are "intersystem model," "total system", and "world system." Chin (1961 : 207) describes an "intersystem model" by pointing out that it involves two open systems connected to each other through such lines of relationships as communications, leadership, hierarchy and authority, the social contract, mutual role expectations, power, conflict, intergroup relations, and so forth. He continues by saying that the intersystem model leads us to examine the interdependent dynamics of interaction both within and between the units.

Terry (1966 : 215 - 220) uses the term "total systems" to refer to the many related systems - the integration of necessary systems within the whole.

By "world system" or "world dynamics" Forrester (1971 : 1) means man, his social systems, his technology, and the natural environment. This idea is an elaboration of his previous concepts of "Industrial Dynamics" (1961) and "Urban Dynamics" (1969) which are two other areas for systems application.

Systems Design and Systems Analysis

While trying to clarify the meaning of the concepts, we need, at this point, to bring in such terms as "systems analysis," "systems design," and "systems engineering." Using a systems framework, many basic and applied sciences have developed sophisticated analytical procedures. The Blalocks (1959 : 84) have suggested that on the most general level that which can be termed "systems analysis" involves a way of thinking which is common to all sciences, whether explicitly recognized or not. They also suggest that such analysis may be carried out from three perspectives : (1) that which involves the relationship between system and environment; (2) which involves interaction between several systems; and (3) which involves one type of system which is composed of other types.

Optner (1960 : 25 - 28), who has more interest in the mechanism of systems analysis, states that the "system module" is used as an analytic tool in investigating the existing systems. An engineer in this field usually takes the following sequence of steps while trying to analyze the system :

1. Identification of the system : processor;

2. Identification of the purpose for which the system exists: output;

3. Identification of the ingredients to produce the required end result: inputs;

4. Identification of mechanisms to maintain reliability and accuracy: controls; and

5. Identification of mechanisms to correct malfunctioning output: feedback.

Systems analysis is seen here only as the first basic step toward redesigning a system. "Systems design" involves three essential steps: (1) investigation, (2) hypotheses, and (3) implementation. At the first step, the existing system is ivestigated through data analysis (systems analysis) and a conceptual model is thus developed which is based on the analysis. The second step is where the conceptual model which has been developed is subjected to a test, and depending upon the results, a new system is proposed. In designing it, particular attention must be paid to the facts known about systems. For example, it is important to know that subsystems are interrelated and that their integration is essential to proper operation. The unit subsystem functions as an integral part of the end item. The outputs of subsystems actually energize higher order than more complex ones. Therefore, each must be analyzed in order to expose the subsystems and put them in their proper relationships to those of a higher order - all with a knowledge of the input-output requirements. Although there are similarities between systems or subsystems, they cease to exist at a certain point, and the unique requirements of each must dominate. Outputs, goals, and so forth, will change from system to system.

Finally, the new system needs to be implemented first through a pilot, then through the full installation.

Johnson and associates (1963 : 258 - 276) state that :

"Systems design is the key activity in implementing the systems concept. This function provides an overall framework by establishing subsystems, larger systems, and a composite, integrated whole. Within this framework and within the philosophical setting of the systems concept, other tools and techniques of management science can be employed, e.g., linear programming, queing theory, network analysis, and work simplification."

Systems design covers the designs of a new system, as well as the redesigning of existing ones, and always with an eye toward change. Systems analysis focuses on existing systems rather than on the design of new ones.

Systems engineering, on the other hand :

"Implies the creation of systems as well as the analysis of the existing systems. Systems engineering sometimes is assumed to deal only with the physical components; that is, it deals with the integration of components and subcomponents into a total product such as a computer or missile. ... Moreover, systems engineering can be defined as 'making useful an array of components designed to accomplish a particular objective according to plan.' This approach implies the interaction of more than equipment. It suggests the development of a man-machine system which could function as a task-oriented assemblage."

Towards a Modern Open Systems Theory

From the discussions above, it is now obvious that the movements of GST and the systems theories, design, analysis, and engineering can be differentiated, but this differentiation will not go very far. The concepts are all interrelated for each are based on the same pattern of thought and have implications for each other. Based upon the degree of abstraction or generality, it is possible to put these movements of the same nature in a hierarchical order. At the top will exist GST, the most abstract and at present the least operational. Below, we can place systems theories or models which are less abstract, thus focusing on a single system in an environment rather than a range of systems - but having more operational implications than the GST. Finally, at the bottom of the hierarchy, and with the least abstraction and most operationality, will be systems design, or engineering, and systems analysis. They represent the ways in which concepts are utilized and may be considered as specific frameworks for the implication of the systems idea, and for making use of analytical tools for the same purpose.

At this stage, drawing upon all the discussions presented so far, let us first define a system and then the systems theory.

We define a **"system"** as **anything which is an integrated whole, composed of interdependent elements and parts which act on each other and in such a way with their constantly changing environment, that the identity of the system is maintained.**

This definition of systems can be applied to almost anything. Let us start with the simplest, a piece of metal. Such a piece is composed of parts called molecules which in turn are made up of elements known as atoms. There are interdependent, interacting and integrated, thus providing a whole - the piece of metal. It is in an environment which is constantly changing. There is some interaction between the metal and its surroundings as, for example, when weather changes, metal will change its size, and perhaps shape and length, in order to adapt itself to the environment. Hence, it gets larger when it is warm and smaller when it is cold. It also has an identity, and is called by a certain name - iron for example, it will continue to be iron as long as its content and nature is the same. But if more water is added, its nature is changed. Therefore, it no longer is iron - it is steel.

Let us apply the same definition of systems to a plant such as a tree. It is also composed of parts which are known as cells. As with metals, these parts too are interdependent and integrated, and interact with one another and with their environment. When the environment changes, the tree changes as well. When there is no more water or too little oxygen or too much carbon dioxide or carbon monoxide, the tree turns yellow and gradually dies. When this transpires, however, it is no longer the same thing or the same system. It becomes wood and its content is different from that of a tree. Its identity has changed, together with its nature and thus has a new means of operation.

The same thing is true for an animal or a human being. They change with a changing environment and under the forces so produced, they either continue to live as organisms or die, and are transformed in nature, thus becoming a system which is referred to as a corpse.

The examples may be multiplied up into the millions, systems themselves being but single objects. There are also the collections, and/or their combinations; hence as we move up from the single unit to the aggregation, systems become more and more complex.

In our study, we are not interested in physical or biological systems, but with those which have been created by human beings for certain purposes and which are usually referred to as "social systems" - organizations. Although the definition of a system we have given above covers such systems as weel, it needs to be elaborated upon, taking into condiration the more specific characteristics of the organization. For this purpose, the definiton of systems can be refined as follows :

1. A system is an integrated whole;

2. It is composed of parts (subsystems) and elements;

3. Each part is a subsystem in relation to other systems of higher ranks - a system in itself - and is composed of further subsystems in relation to other systems of lower ranks;

4. Parts of a system are interdependent; they cannot be independent of each other because in this case there will not be a whole and we cannot talk about integration;

5. There is a dynamic interaction among the parts and elements of a system;

6. There is also a dynamic interaction between the system, its parts and elements and the environment. This points to the fact that;

a) Every system has an environment;

b) A social system is an open system and has no rigid or fixed boundaries. The boundaries are not anything more than some assumed lines drawn for analytical purposes;

c) Interaction among, and integration of, parts and elements are of greater magnitude and intensity inside the boundaries than those outside the boundaries; and

d) A system can never be isolated from its environment and be independent of other systems in the environment;

7. Environment is subject to continuous change, and a system is a part of that changing milieu; therefore,

8. To survive, to maintain its identity, and/or to grow and develop, a system (a) is also subject to continuous change, and it must adapt itself to the changes in the environment, (b) needs to get **inputs** from the environment, no matter what they are, (c) should process these inputs **(throughputs)**, (d) should produce **outputs** and export them into the environment, (e) should have a **feedback** mechanism to obtain the information about the results or conssequ-

ences of its outputs, and (f) should have **control** mechanisms to direct :

(1) Deviations from the normal route of operation,
(2) Inputs coming into the system, and
(3) Entropic elements operating within and without the system;

9. A system constantly changes and while changing, it strives for an orderly transition or for order in the change process to prevent chaos and confusion. Striving for order does not mean a "steady state" or "equilibrium" which have static connotations. Even such terms as "dynamic equilibrium," "practical equilibrium," or "quasi-equilibrium" are misleading because they imply a cyclic change process of a stop and then a move which does not reflect the realities of social systems; and

10. A social system is goal-oriented; it has been created to achieve certain aims. These may be a variety of things or their combinations - survival, growth, change or adaptation, profit-making, production of material and services, satisfaction of clientele, and so on. It is this fact which gives a system its identity. However, both the identity and its goals are also subject to change. It is even possible that it might exist without a goal, but only temporarily.

At this point, we are now in a better position to define **"systems theory,"** which is **the body of knowledge generated, the set of relatively common propositions or hypotheses set up** (listed above) **for study, explanation and the prediction concerning the nature and operation of systems, as well as their changes and consequences.**

Nature of Systems Theory

Systems theory, first of all, is an epistomological device; it offers a systematic way of dealing with complexity; it is utilized as a tool for conceptualizing a phenomenon, an object, an organism, their combinations, and so forth. It is a means of putting propositions or hypotheses, or existing facts together, or theorizing to explain, understand, or make predictions about the nature of a system. In this meaning systems imply both the general theory and the models and as such, are broad conceptualizations in systems terms. The difference between the two is one of a degree of abstraction, operationality, and the area which they cover.

Second, systems theory is a collection of terms or concepts to be used while theorizing about the nature of a system.

Third, at operational level, a systems theory is the framework in which a certain system may be analyzed. In this usage it is referred to as "systems analysis" or "systems design."

Fourth, the term "systems" implies perfection, efficiency, and effectiveness which is obtained through the design of a new system or redesign of an existing one within the provided framework.

Fifth, systems theory can also be considered to be a method of changing modes of operation.

Finally, a systems notion is an attitude, an approach, a way of thinking, and a research methodology.

Advantages of the Systems Approach

Now let us point out some of the advantages of the systems approach :

1. It supplies a realistic look at a system. It helps to comprehend the entirety, to see the whole, yet appreciate the operation of various parts separately - and as a group - in achieving a particular goal.

2. It has the impact of a change in the environment, or in any one of its parts or elements, effecting each and all other parts, and thus making them more understandable, more explainable, and more predictable.

3. It helps in achieving more accurate and reliable plannig for the design of a new system or redesign of an already existing one.

4. It emphasizes accurate and reliable controls.

5. It increases appreciation of the total problem. Complex, intricate ones that extend into every facet of the system can be handled satisfactorily by this theory. The difficulties may be clearly identified, and the problem areas can then be isolated.

6. Ingredients and requirements may easily be identified and overlappings or duplications, unnecessary inputs and waste, can be eliminated or minimized through the use of the systems theory.

7. The systems theory facilitates the utilization of present-day data processing equipment, and through its use the processing may be automated.

8. Day-to-day analysis or special studies can be provided, and they may be performed as a by-product of the total effort with little cost and effort.

9. Finally, the systems theory brings savings, better coordination, greater efficiency and effectiveness in the operation of systems.

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Ö Z E T

ÇAĞDAŞ BİR AÇIK SİSTEM KURAMINA DOĞRU

"Sistem" günümüzde sosyal ve davranışsal bilimlerin çalışma alanlarında sözü en çok edilen kavramlardan biri haline gelmiştir. Çalışmalara geniş ölçüde konu olmakla beraber, bu kavramın sosyal ve davranışsal bilimlerdeki anlamı üzerinde henüz tam bir fikir birliğine varılmış değildir.

Bu çalışma "sistem" kavramının anlamını açıklığa kavuşturmak amacına yönelmiştir. Bu amaçla, sistem konusunda genel olarak yapılmış çalışmalar ile çeşitli sistem kuramları gözden geçirildikten sonra, çok sayıda düşünürün sistem kavramına ilişkin ortak ya da benzer düşüncelerine dayanılarak önce bu kavramın bir tanımı verilmiş, daha sonra da çağdaş bir açık sistem kuramının nitelikleri sıralanmış, çerçevesi çizilmiş ve böyle bir kuramın tanımı yapılmaya çalışılmıştır.

Çalışmanın önemli bir kısmı, sistem düşüncesinin çeşitli alanlara uygulanması ile geliştirilen sistem kuramlarının gözden geçirilmesine ayrılmıştır. Bu arada, Stanford L. Optner, Ludvig von Bertalanffy, George C. Homans, David Easton, Talcott Parsons ve Walter Buckley gibi düşünürlerin bu alandaki çalışmaları özetlenmiştir. Çalışmanın diğer önemli bir kısmında ise "Genel Sistem Kuramı" üzerinde durulmuştur. Genel Sistem Kuramı ile çeşitli sistem kuramları arasındaki ilişkiler incelenmiş, ikisi arasında önemli farklar bulunmadığı sonucuna varılmıştır. Ayrıca, Genel Sistem Kuramı, sistem kuramları, sistem modelleri, sistem yaklaşımı, sistem tasarım ve sistem çözümleme gibi kavramlar arasındaki ilişkiler açıklığa kavuşturulmuştur.

Sistem düşüncesinin örgüt ve yönetime uygulanışı bugün o derece yaygındır ki, bu yöndeki çalışmaların kısaca da olsa bu çalışmanın kapsamı içinde gözden geçirilmesine olanak bulunamamış, konunun bunun devamı sayılabilecek ikinci bir çalışmada ele alınması uygun görülmüştür.

Bu çalışmada sistem düşüncesine ilişkin kavramlar tanımlandıktan, çeşitli sistem kuramları kısaca gözden geçirildikten ve genel bir açık sistem kuramının çerçevesi çizildikten sonra, son olarak, sistem yaklaşımının özellikleri ve sağladığı yararlar üzerinde durulmuştur.