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INTER- AND TRANSDISCIPLINARY UNIVERSITY: A SYSTEMS APPROACH TO EDUCATION AND INNOVATION

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ABSTRACT

In response to various pressures for change arising from the present situation, the university will have to adopt a new purpose which may be recognized as a means of increasing the capability of society for continuous self-renewal. With this new purpose in mind, the structure of the university will be determined by the concept of an integral education/innovation system for which four principal levels are considered: empirical, pragmatic, normative and purposive levels. From multi-, pluri-, and crossdisciplinary approaches, all pertaining to one systems level only, the university is expected to develop increasingly interdisciplinary approaches, linking two systems levels and coordinating the activities at the lower level from the higher level through common axiomatics. Ultimately, the entire education/innovation system may become coordinated as a multilevel multigoal hierarchical system through a transdisciplinary approach, implying generalized axiomatics and mutual enhancement of disciplinary epistemology. Current university approaches to develop interdisciplinary links between the pragmatic and normative systems levels are discussed. Finally, a transdisciplinary structure for the university is briefly outlined; its main elements are three types of organizational units–systems design laboratories, function-oriented departments, and discipline-oriented departments–which focus on the interdisciplinary coordination between the three pairs of levels in the education/innovation system, i.e., on method and organization rather than on accumulated knowledge. An important role for policy sciences is seen in the linkage between the top pair of systems levels.

1. A Heritage of "Autonomous" Science and Higher Education

Current discussions about university reform usually start at the wrong level, focusing either on problems of operating existing types of universities or on innovation in the didactic approaches and curriculum reform. In other words, tactical and strategic questions are debated before policy–namely the role of education as an institution of society–has been made explicit. With the focus on higher education, there is also an intimate link between science and education and their institutional roles in society to be explored beforehand.

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We are living in a time in which both institutions, science and education, are ascribed vastly differing roles by different people, with a confusing variety of policies implicitly entering the discussion. This is only one more indication that we live in a time of transition with respect to thought and action. In this paper, a tentative general policy for science and education will be proposed on the grounds of being relevant to the present situation—the technological era, and the transition from the industrial to the postindustrial society in the highly developed regions of the world—and implications for the university will be developed.

The conventional views of the role of science may best be discussed in terms of the four theories of science planning outlined by Harvey Brooks (1968). Three of them negate any feedback from social innovation to science: the Michael Polanyi/Derek Price view of science as an autonomous enterprise and the system of science as an entirely self-regulating community underlies one of these theories. As Brooks observes, "whereas the Polanyi school [tends] to regard science as a delicate plant, which would wilt if interfered with by society, Price seems to regard science as a vigorous weed that society could not interfere with even if it desired," which leads to different behavioral patterns in the academic community. The second theory, science as a consumer good, or generally an autonomous cultural expression, finds its contemporary protagonists in H. G. Johnson and Stephen Toulmin. It views science as part of the basic purpose of society, and may be regarded as the modern version of the attitude which drew an analogy between science and the arts as the creative domain of the individual, and which dominated through centuries. The third theory, science as a social overhead investment, assumes that science "underlies *all* the purpose of society, and is therefore to be carried out in an organizational structure which is patterned on the conceptual structure of knowledge " (See also the corresponding theory of levels of knowledge by Jean Piaget, outlined in Section 3 of this article.) It links science to social innovation in a nonspecific way, but preserves, like the first two theories, a belief in an "internal ecology of science" which remains unaffected by feedback from social innovation.

Science as viewed by these three theories is concerned with *what is* rather than with *what ought to be.* Such science has been called by Churchman (1968, p. 83) "simply a defective part of the social organization."

Only the fourth theory, Alvin Weinberg's view of science as a technical overhead on social goals, by focusing on the achievement of certain social goals through technology establishes a direct relevance of social goals to scientific activity. It hardly conceives science and society as aspects of a comprehensive system, but looks at direct relationships between goals of a strategic character and technological contributions toward them.

The first three views of the role of science have been nurtured into veritable myths by partisans of a misinterpreted "academic freedom," who are even stronger in Europe than in America and who have prompted the Russian physicist Artsimovich (1969) to remark: "If I understand correctly, in the Western countries just like in the Soviet Union, a scientist is called somebody who is permitted to pursue his hobby at the expense of society." These myths find their equivalent in views of the university (Drèze & Debelle, 1968)[1] as "a community of research scholars" (Karl Jaspers), "an intellectual mould" (Napoleon), or "a center of progress" (Alfred North Whitehead).

The current structure of the university, and even of the modern institute of technology, is still largely determined by these views, expressing a profound belief in a *laissez-faire* type self-organization of science and technology. The "autonomy" of science in the university has recently been emphasized again in the discussions around the role of the American university: Columbia University, in the words of its Vice President (Kusch, 1969), will try to redefine itself as "the seat of learning and of knowledge"; part of the faculty of the Massachusetts Institute of Technology[2] professes to a purpose of the university contained in the notion of "the building of intellectual capital and its dissemination"; and the (then) President of Cornell University (Perkins, 1968) saw the primary purpose of the university in its forming a more or less self-contained community.

The polarization of education as "a source of economic growth" (Tu, 1969)[3] and the university as "a factor of production" (Council of Ministers of the USSR) (Drèze & Debelle, 1968) does not question the structure of the university in a profound way, since economic planning for the university, as in other domains, prefers to pursue a linear rationale, acting on variables (numbers of students, etc.), not on structures. It usually tries to orient the university toward a rigid model of society, with well-defined and unchanging patterns of professional specialization, placing emphasis on growth within this predetermined framework. Again, feedback from social innovation to science is neglected.

Of all four theories of science planning, cited above, only the Weinberg view of science as a technical overhead on social goals suggests a reorganization of scientific activity in line with recognized social goals. This reorganiza-

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[1] The other two concepts of the university discussed in this book are "an environment for education" (J. H. Newman), and "a factor of production" (Council of Ministers of the USSR).

[2] Faculty meeting, Sloan School of Management, Massachusetts Institute of Technology, May 1969.

[3] It is interesting to note some of the other notions of education, held by economists from Adam Smith to Pigou: "an investment in human beings"; "a consumer durable par excellence"; "a political good in that it preserves law and order"(!); "a social good in that it contributes to the diminution of crimes and enhances social mobility"; "a factor making for more equal income distribution"; etc.

tion takes the form of normative, though fragmented, interdisciplinary approaches as will be explained in Sections 3 and 4 of this article. A certain danger may be seen here in the temptation to take a straightforward (nonsystemic) problem-solving approach of the type which has proved so successful in attaining purely technological targets, and to neglect the systemic character of most of these problems in the social area.

The same pressure for change is recognized by Clark Kerr (1967) in the growing conflict between undergraduate education on the one hand, and university research, graduate training, and service on the other. He diagnoses this conflict as one between generalization and specialization, as well as between external orientation—toward the outside community, government, industry, and the professions, etc.—and internal orientation, toward the student.

Generally speaking, the obsolete state of theoretical thinking about the roles of science and education is, to a large extent, due to a fixation on the search for assumed *inherent* organizing principles and criteria, valid *a priori* and independent of social activity—essentially a static view, which may have been consonant with past cultural patterns and states of society, but certainly is "out of tune" with the world of today. This fixation may be regarded as one of the principal factors enhancing the resistance to change of the current institutional and instrumental patterns of the university. On the other hand, the dissatisfaction of students and parts of the faculty with the "autonomous" elite approach of science and higher education forces a reconsideration of their institutional roles.

A systems approach, going beyond the four conventional theories of science planning outlined above, would consider science, education, and innovation, above all, as general instances of purposeful human activity, whose dynamic interactions have come to exert a dominant influence on the development of society and its environments. A new policy as well as new structures for the university may be expected to emerge from such an approach. They will constitute responses to the *specific situation* in which society finds itself today, and will be subject to continuous change. As a matter of fact, they ought to be designed explicitly with a view toward their innate capability for flexible change in accordance with the dynamically evolving situation. In the following chapters, a possible systems approach to educational policy, an integral view of science, innovation, and higher education, and the role and structure of the university will be developed with the aim of matching these requirements.

2. Education for Self-Renewal

We are living in a world of change, voluntary change as well as change brought about by mounting pressures beyond our control. Gradually, we are learning to distinguish between them. We engineer change voluntarily by pursuing growth targets along lines of policy and action which tend to rigidify and thereby preserve the structures inherent in our social systems and their institutions. We do not, in general, really try to change the systems themselves. However, the very nature of our conservative, linear action for change puts increasing pressure for structural change on the systems, and in particular, on institutional patterns.

We are baffled by the sudden appearance of such pressures for change in the educational system by student unrest and by the notion that the current type of education may no longer be relevant. We are confused by the degrading side effects of technology on the systems of human living, in the cities as well as within the natural environment. And we are ridden with doubts about the effectiveness of decisionmaking processes dominated by short-range and linear thinking and about the piecemeal and passive way in which scientists and engineers respond to them. Through its three functions—education, research, and service—the university is deeply affected by all of these pressures for change. To live with them, to absorb them and even make use of them, requires a new purpose and a new structure for the university.

Looking at changes, and pressures for change, in all three of the primary functions of the university, we may, *inter alia,* discern the following important trends:

–*Education:* From training for well-defined, single-track careers and professions (by duplicating existing skills) toward an education which enables judgment of complex and dynamically changing situations—in other words, geared to the continuous self-renewal of human capabilities, with emphasis shifting from "know-how" to "know-what."

–*Research:* From discipline-oriented research over pluri- and interdisciplinary research toward research on complex dynamic systems—or, from research on the fundamental level and the perfection of specific technologies to the organization of society and technology in a systems context.

–*Service:* From specialized, piecemeal research contributions and passive consultations to an active role in the planning for society, in particular, in the planning of science and technology in the service of society.

A synopsis of the pressures for change, as recognized above for the individual functions of the university, and those for change in society at large, yields a picture of powerful forces which act disruptively within the existing structures, but seem to converge reasonably well in their ultimate meanings and implications. The new purpose of the university may readily be found in this area of convergence of reason. It may be expressed as the new purpose of the institution itself, not of its members.

In most general terms, the purpose of the university may be seen in the decisive role it plays in *enhancing society's capability for continuous self-renewal.* It may be broken down further in line with the principal characteristics of a society having this capability, as spelled out by John Gardner (1965):

- *Enhancing the pluralism of society,* by bringing the creative energies of the scientific and technological community as well as of the young people, the students, fully into play—not for problem-solving, but for contributing to society's self-renewal;
- *Improving internal communication among society's constituents* by translating into each other the mutual implications of science and technology on the one side, and social objectives on the other, and by pointing out the long-range outcomes of alternative courses of action in the context of broadly conceived social systems;
- *Providing positive leadership* by working out measures of common objectives, setting priorities, and keeping hope alive, as well as by promoting experiments in society through ideas and plans, and, above all, by educating leaders for society.

The new purpose implies that the university has to become *a political institution* in the broadest sense, interacting with government (at all jurisdictional levels) and industry in the planning and design of society's systems, and in particular in controlling the outcomes of the introduction of technology into these systems. The university must engage itself in this task as an institution, not through the individual members of its community.

The university ought to become society's strategic center for investigating the boundaries and elements of the recognized as well as of the emerging "joint systems" of society and technology, and for working out alternatiye propositions for planning aimed at the healthy and dynamically stable design of such systems.

The major changes which this new purpose will bring to the university, include the following ones:

—Principal orientation toward sociotechnological systems design and engineering at a high level, leading to emphasis on general organizing principles and methods rather than specialized knowledge, both in education and research.

—Emphasis on purposeful work by the students rather than on training.

—Organization by outcome-oriented categories rather than by inputs of science and technology, and emphasis on long-range outcomes.

With the new purpose, the education, research, and service functions of the university, which have increasingly become more widely separated, will again merge and, in fact, become one. This emerging unity corresponds to an integral view of the education/innovation system which will be elaborated in the following section.

3. The Education/Innovation System

If education is accepted as being essentially education for the self-renewal of society, it becomes an important, or even *the* most important agent of innovation. Going even further, we may speak of an integral education/innovation system in which both education and innovation become aspects of one and the same structure of thought and action. Such an education/innovation system constitutes a most suggestive example for the systems notion in line with Mesarovic's recent definition (1969): "A system is a relationship among objects described (or, specified, defined) in terms of information processing and decision-making concepts."

Scientific, or more generally, educational disciplines become organized in such a system in a particular way which depends on the normative orientation of education and innovation. The boundaries of disciplines, the interfaces, and the relationships between them no more correspond to an *a priori* system of science. It may therefore be considered appropriate to speak simply of an education/innovation system, instead of a science/education/innovation system, in order to emphasize the viewpoint of a human action model, not a mechanistic model. Knowledge is understood here as a way of doing or "a certain kind of management of affairs" (Churchman), a notion which differs radically from all four conventional theories of science planning outlined in Section 1. Figure 1 attempts to sketch such an organization in the form of a multilevel hierarchical system. The point of view applied here is that of the improvement of the system of human society and its environment—a *partisan* viewpoint which starts from the assumption that man has become the chief actor in the process of shaping and controlling the system. It may be called the *anthropomorphic angle of view* which, by definition, cannot be "objective." Nor would it be possible at all to form the notion of an integral education/innovation system without a purposive, and thus "subjective" view in mind.

The traditional dissection of knowledge and knowledge transfer into a variety of disciplines has been developed from another angle of view, namely that it should be possible to arrive at a mechanistic explanation of the world *as it is* by putting empirical observation into a logical context. Disciplinarity in science is essentially in static principle which becomes meaningless if considered in the framework of a purposive system. It is no wonder that in a time when science is increasingly understood as a basis for or oven an integral aspect of creative human action, the emphasis shifts to more or less interdisciplinary approaches. However, it has not yet become fully clear what interdisciplinarity and the intermediate steps toward it really mean.

Above all, interdisciplinarity has to be understood as a *teleological and normative* concept. We must ask: *Interdisciplinarity to what end?* It involves

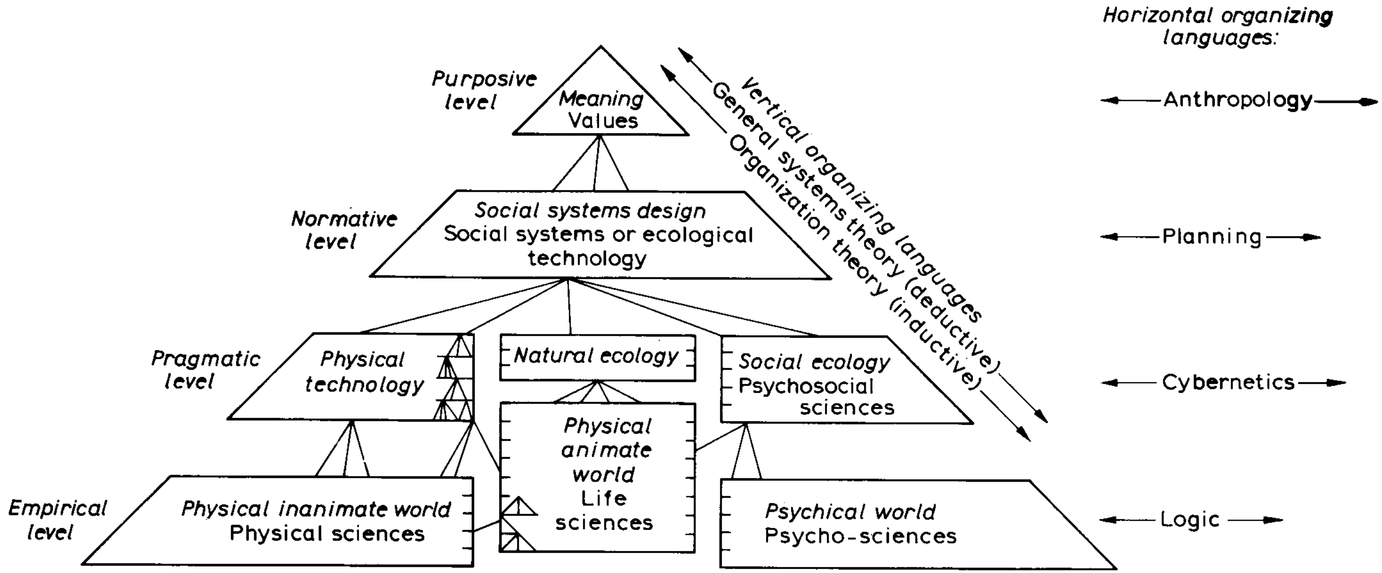

Figure 1. The education/innovation system as a multilevel multigoal hierarchal system. Branching lines between levels and sublevels indicate possible forms of interdisciplinary coordination.

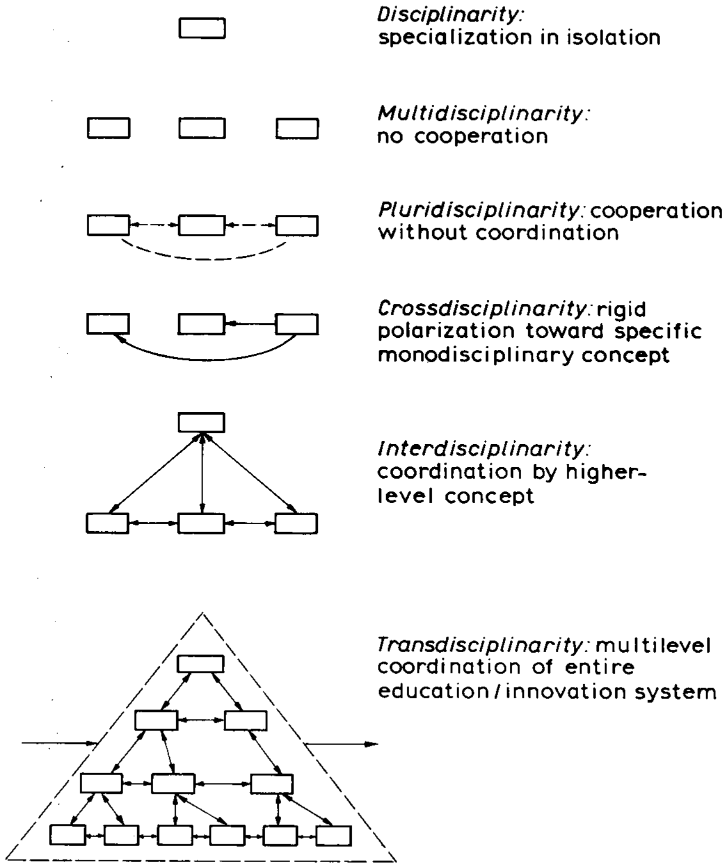

Figure 2. Steps toward increasing cooperation and coordination in the education/innovation system.

the organization of science toward an end, in other words the linking of adjacent hierarchical levels in the education/innovation system, as sketched in Figure 1. The various steps of cooperation and coordination among disciplines, as they are currently discussed with a view to educational needs,[4] may now be defined in the following way (see Figure 2):

–*Multidisciplinarity:* A variety of disciplines, offered simultaneously, but without making explicit possible relationships between them.

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[4] Only the notion of crossdisciplinarity has been added here. The basic evolutionary ladder is usually well recognized, but the system building character of inter- and transdisciplinarity is not. As a result, the boundaries between pluri- and interdisciplinarity often become blurred in current discussions.

–*Pluridisciplinarity:* The juxtaposition of various disciplines, usually at the same hierarchical level (i.e., empirical or pragmatic), grouped in such a way as to enhance the relationships between them.

–*Crossdisciplinarity:* The axiomatics of one discipline are imposed upon other disciplines at the same hierarchical level, thereby creating a rigid polarization across disciplines toward a disciplinary axiomatics.

–*Interdisciplinarity:* A common axiomatics for a group of related disciplines is defined at the next higher hierarchical level, thereby introducing a sense of purpose; more specifically, we may distinguish between *teleological interdisciplinarity* at and between the empirical and pragmatic levels and sublevels, *normative interdisciplinarity,* signifying the important step from the pragmatic to the normative level (where the question of "good" and "bad" is raised), and *purposive interdisciplinarity,* bridging from the normative to the purposive level.

–*Transdisciplinarity:* The coordination of all disciplines and interdisciplines in the education/innovation system on the basis of a generalized axiomatics (introduced from the purposive level) and an emerging epistemological pattern.

It should be noted here that the four hierarchical levels, depicted in Figure 1, are further subdivided into a fine structure of hierarchical sublevels. For example, there are such levels between basic technologies and complex technological systems. The notion of interdisciplinarity may also be applied to links between these sublevels. The essential is that a new common axiomatics can be introduced from the higher level.

With the above notions of inter- and transdisciplinarity, the education/innovation system according to Figure 1 assumes a specific meaning in system-theoretical terms. Without these notions, it might at first glance appear as a *stratified system*[5] where the different strata signify levels of abstraction. Each stratum would then have its own set of terms, concepts, and principles. Crossing the strata in the downward direction would give increasing detailed explanation, while crossing them in the upward direction would give increasing significance. Empirical science, in many instances, has been developed in such a stratified way; the example of the biological sciences with their strata from whole organisms and organs down to cells and further to molecules provides here the most suggestive example.

Interdisciplinarity, however, as has already been implied above, constitutes an *organizational principle.* It leads to a two-level coordination of terms, concepts, and principles which is characteristic of *a two-level multigoal system* (see, for example, Mesarovic *et al.*, 1970). The important dif-

[5] For the different concepts of hierarchical systems, see Mesarovic & Macko (1969).

ference here is that *with the introduction of interdisciplinary links between organizational levels the scientific disciplines defined at these levels change in their concepts, structures, and aims.* This is usually overlooked in superficial attempts to bring together specialized knowledge and methods in research and education—most of the approaches called "interdisciplinary" today are at best pluridisciplinary or crossdisciplinary!

The ultimate degree of coordination in the education/innovation system, finally, which is called transdisciplinarity in the above classification, would not only depend on a common axiomatics—derived from coordination toward an "overall system goal"—but also on the mutual enhancement of epistemologies in certain areas, what Ozbekhan (1970a) calls "synepistemic" cooperation. With transdisciplinarity, the whole education/innovation system would be coordinated as a *multilevel multigoal system,* embracing a multitude of coordinated interdisciplinary two-level systems. Transdisciplinary concepts and principles over the whole system change significantly with changes in the "overall system goals," toward which the top coordination function of "meaning" in Figure 1 is oriented. For example, the adoption of a notion of "progress" at this top level would imply a totally different education/innovation system from one for which "ecological balance," or a notion of cyclical development, are adopted. Ferkiss (1969) has pointed to the linear "progress" thinking in Christian thought as the historical roots of Western economic and technological dynamism. We arrive here at the same crossroads as in all attempts to view whole systems and aim at their improvement: we lack a deeper understanding of purpose, and thus an unambiguous direction for our organizational efforts. Nevertheless, we cannot hope to act with a true purpose—in other words, to manage the multilevel multigoal education/innovation system in a meaningful way—if we do not search for and bring into play values and norms, a *policy for mankind,* to guide education and innovation. This task is, on the one hand, an aspect of policy formation and institutional renewal—and thus part of the domain of policy sciences (Jantsch, 1970)—and on the other hand its very motor, if education and innovation are supposed to be geared to the self-renewal of society.

An autonomous self-sufficient system of "value-free" (purposeless) science would be built in an entirely different way. It is most important to understand that the education/innovation system according to Figure 1 is a system serving a human purpose. The autonomous science system would not lead to a multilevel coordination in which each level is "alive" with its own purposes, but to a rigid stratified system, built, for example, of the four levels of knowledge proposed by Piaget (1964, pp. 1174 ff.). The "material" level (the sets of objects of distinct sciences); the "conceptual" level (the body of systematized knowledge, or methodology); the "internal epistemological" level (critical analysis of basic principles and viewpoints); and the "derived epistemological" level (where all sciences are related to each other, where a generalized epistemology begins to emerge, and where approaches can be unified on the basis of a generalized axiomatics). Inter- and transdisciplinarity may be understood here not as organizing principles, but as steps on a rigid ladder of levels, more specifically as science elevated to the two highest strata of knowledge.[6] This, however, corresponds to a mechanistic view, embracing also the social sciences, which is unacceptable. In any case, it should be kept in mind that the design and substance of the education/innovation system depends primarily on the purpose attached to it. That is the reason why all discussion about educational concepts at *all* systems levels has to start with a discussion of purpose.

Other attempts seek to elaborate on Karl Mannheim's sociological approach to science, his "Wissenssoziologie," and to conceive science in the framework of a "social construct of reality." (See, for example, Berger & Luckmann, 1969.) But, generally, they take a phenomenological approach today which fails to perceive a dynamic and purposive science/innovation system. Most of these attempts try to preserve science as a "value-free" abstraction. The spearheads of a critical sociology (e.g. Herbert Marcuse), who do recognize the dynamics of social innovation and the role of science as instance of human activity, usually disregard the full human potential of purposive design of the social reality through the overall science/innovation system. Moreover, they tend to impose the axiomatics of their approach in a crossdisciplinary way instead of developing possibilities for a normative interdisciplinary organization of technology and the social and life sciences.

From a systems point of view, the successive steps of cooperation and coordination between disciplines in the system sketched in Figure 1 may now be defined as organizational principles for hierarchical systems of the following types:

–*Multidisciplinarity:* One-level multigoal; no cooperation.

–*Pluridisciplinarity:* One-level multigoal; cooperation (but no coordination).

–*Crossdisciplinarity:* One-level one-goal; rigid polarization towards a specific disciplinary goal.

–*Interdisciplinarity:* Two-level multigoal; coordination from higher level.

–*Transdisciplinarity:* Multilevel multigoal; coordination of whole system toward a common goal.

Multi- and pluridisciplinarity involve only the purposeless or purposeful

[6] Prof. Guy Michaud of the University of Paris explains multi-, pluri-, inter-, and transdisciplinarity by analogy to Piaget's four levels of knowledge. (Preparatory papers for the Seminar on Pluridisciplinarity and Interdisciplinarity in Universities, sponsored by OECD, Nice, 7–12 September 1970.)

grouping of rigid (disciplinary) "modules." Crossdisciplinarity implies a "brute force" approach to reinterpret disciplinary concepts and goals (axiomatics) in the light of one specific (disciplinary) goal and to impose a rigid polarization across disciplines at the same level. Only with inter- and transdisciplinarity the education/innovation system becomes "alive" in the sense that disciplinary contents, structures, and interfaces change continuously through coordination geared to the pursuit of systems goals. *Inter- and transdisciplinarity thus become the key notion for a systems approach to education and innovation.*

The education/innovation system, as sketched in Figure 1, is built from the bottom level upwards. This is inevitable since, in a multilevel multigoal system the upper organizational levels cannot achieve anything without the activities at the lower levels, just as a conductor cannot achieve anything without an orchestra. On the other hand, this means that two major obstacles on the way to inter- and transdisciplinarity have to be overcome: One is the rigidity of disciplines and disciplinary concepts and axiomatics developed at the lower levels; the other one is the application of lower-level concepts and axiomatics to higher levels. Both obstacles, indeed, prove very severe in the development of a meaningful social science and in current approaches toward an interdisciplinary social technology, as will be briefly discussed below.

The *empirical level* in Figure 1, with *logic* as its "organizing language," may be subdivided into three bodies of science which all developed on the basis of empirical observation and logical interpretation: (a) physical sciences, with the traditional disciplines; (b) life sciences, which occupy a special position and overlap both empirical and pragmatic levels, also extend from basic knowledge up to complex biological systems and thus extend over both organizational levels; and (c) psycho-sciences, which include psychology and the behavioral sciences as well as aspects of human perception and creative expression, such as the arts and religions. These sciences aim at describing the world as it is and at being "objective," a concept which is at least doubtful in the domain of the psycho-sciences. Interdisciplinary types of teleological coordination have become fruitful particularly between hierarchical levels within the physical sciences as well as between physical and life sciences (e.g. biochemistry on the one hand, molecular biology on the other).

The *pragmatic level* with *cybernetics* as common "organizing language" represents a higher level or organization and may be subdivided into: (a) physical technology, embracing many hierarchical sublevels from basic technology over simple products to complex technological systems together with their functional interactions with societal systems; (b) the more systemic part of the life sciences, and natural ecology, which has been successfully used to develop agriculture; and (c) social ecology, or simply culture, based on psychosocial sciences, comprising, *inter alia,* history, sociology, linguistics, and communication in general, communicative aspects of the arts, microeconomics, political science (in its narrow pragmatic meaning), cultural aspects of anthropology, and the traditional ethics of the individual. Or, rather, there ought to be such a science of social ecology, applicable in a pragmatic way.

One of the two obstacles mentioned above prevented so far the full establishment, in an interdisciplinary way, of the pragmatic level. The "scientific method," and mainly its basic empiricism, were transferred to the pragmatic level. Physical technology, in many instances, first developed on the basis of empirical observation and logical interpretation, e.g. the steam engine, the steam turbine, aircraft, to mention just a few. But all these technologies quickly became interdisciplinary melting pots for various physical sciences when the need for manipulability, and therefore for theory, arose. To what extent the technology-oriented axiomatics "trimmed" the concepts of physical science is demonstrated by chemical engineering or reactor core physics, where complex interactions of microphenomena are cast into handy macrophenomenal theories which suit the needs of specific pragmatic uses of technology to perfection.

Such a swift adaptation did not take place in the area of social ecology or the psychosocial sciences. Here is the profound reason for the frequently denounced lagging behind of the social sciences. As Churchman (1968, p. 85) remarks, "perhaps one of the most ridiculous manifestations of the disciplines of modern science has been the creation of the so-called social sciences," which pursue the same mechanistic ideal of "objective" empiricism as the physical science disciplines. "Instead of social science partitioning itself into special disciplines, it should recognize that social science is not a science at all unless it becomes a natural part of the activities of social man." Above all, social science ought to express the potentials of human freedom, creativity, and responsibility. Instead of yielding to becoming pragmatic or goal-oriented in its concepts, social science, particularly in the United States, is becoming infested with reductionist concepts of the behavioral sciences. Neither the old analytical nor the younger phenomenological schools of social science tell us how to conduct our social life, but tend to discourage us from developing any pragmatic or normative, i.e. value-dependent, social science by making us believe that social science is inherently data-rich and theory-poor. The vigorous development of a critical sociology has increased our understanding of the interrelationships between technology and social science, but does not yet provide the building blocks for a normative social science.

The *normative level,* with *planning* as its "organizing language," deals with social systems design, bringing into focus social systems or ecological technology. It has as its core Churchman's (1968, p. 85) "ethics of whole systems" and branches out into aspects of social systems technology such as law, macroeconomics, and institutional innovation. Typically, it focuses on large social and man/environment systems, ekistics, and a variety of "joint systems" of society and technology. (For this concept, see, for example, Jantsch, 1969a). Few of the domains at this level have yet found valid frameworks–ekistics may be farthest advanced in this respect–and the current concepts of law and macroeconomics hardly meet the interdisciplinary challenge posed to them in the technological era. It is at this level that the broad conceptualization of man's active role in shaping his own and the planet's future unfolds.

The *purposive level,* finally, brings values and value dynamics into play through interactive fields such as philosophy, arts, and religions, structuring in an interdisciplinary way some of the domains at the normative level. The "organizing language" at this level ought to be *anthropology* in its most profound sense, the science of how to create an anthropomorphic world and how mankind may become capable of surviving dynamically changing environments. That most of anthropology today is not much more than an empirical behavioral science, illuminates drastically the confusion created in modern science by the traditional cultural postulate of "knowledge per se" and the corresponding emphasis on empiricism.

It appears futile to discuss what, in the education/innovation system, should be called science and what not. In a narrow, positivistic sense, the notion of science applies only to the lowest systems level. Whether this science is organized and coordinated again by science or by categories of thought, which are given other names, is a matter of arbitrary definition. Essential is only that inter- and transdisciplinary organization and coordination of science are necessary for education and innovation to follow the purpose of society's self-renewal.

The horizontal "organizing languages" of logic, cybernetics, planning, and anthropology, in order of increasing systemicity, intermesh with the vertical "organizing languages" of *general systems theory* (deductive) and *organization theory* (inductive). If the education/innovation system is viewed as a purposive system for the self-renewal of society, as outlined above, we should, in Ozbekhan's words (1970b), "be able to investigate in a more orderly way than has hitherto been possible, whether methodologies arising from anthropology and general systems theory–both of which deal with phenomena that pertain to whole groups–might not be forged into a methodological structure for planning." With such a structure for planning it will then be possible to link the normative, pragmatic, and empirical levels in an interdisciplinary way and ultimately aim at a genuine transdisciplinary coordination, i.e. at managing the education/innovation system in an integral way.

4. Current Approaches toward Normative Interdisciplinarity in the University

How far has the university gone in penetrating the education/innovation system? Clearly not very far yet. In particular, the education function of the university was not capable of adjusting to the requirements of interdisciplinary organization beyond the level of elementary technology. To a large extent, education in technology is still categorized by disciplines and departments called "mechanical engineering," "electrical engineering," "chemistry," etc. This has led to two grave consequences: one is a schism between the education and research functions of the university at levels of higher interdisciplinary organization, which is already becoming a problem at the level of complex technical systems; university research and development in these areas is increasingly set up and carried out outside the educational structures. The other consequence is a growing mismatch between engineering education and the requirements of industry which is reorganizing itself in terms of technological or even sociotechnological systems tasks. In the contemporary institute of technology computers and information technology still are subsumed under "electrical engineering"; no wonder, then, that the particularly strong systemic interaction between man and computer has not yet found a place in the university.

The sore state of social science will not improve rapidly where conventional social science departments deal with the conventional wisdom of empirical or behavioral social science. However, innovative university programs, particularly geared to undergraduate study, are paving the way to a meaningful pragmatic and normative social science. Theme Colleges of Community Science and of Creative Communication at the Green Bay campus of the University of Wisconsin provide a good example here. Even more significant may become the influence of systems-oriented educational and research programs, such as Urban, Regional, and Environmental Centers or Departments which may be expected to create their own approaches to social science if what is readily available has to be judged irrelevant for social systems design.

In the meantime, the social side of the education/innovation system produces a number of crossdisciplinary approaches which all have in common that they fail to recognize the systemic character of science and technology as integral aspects of the "joint systems" of society and technology. One of the most conspicuous attempts of crossdisciplinary polarization is the reformulation of management, planning, and organization—even explicitly the planning of change (e.g. Bennis *et al.*, 1969)—in terms of the empirical and reductionist concepts of the applied behavioral sciences. Other cross-disciplinary attempts to dominate a level of the education/innovation system by imposing narrow disciplinary concepts, start from economics. The Organization for Economic Cooperation and Development (OECD), for example, has applied purely economic criteria and linear methods (econometrics) to education and to scientific research and development and is setting out to do the same to environmental problems and aspects of sociotechnological systems (through a crude economy/diseconomy approach).[7] The recent and drastic failure to explain, or at least describe the "technological gap," a truly systemic phenomenon,[8] in disciplinary terms—as an economic or trade gap, a market gap, a license and royalties gap, a technological development gap, a management gap, an educational gap, etc.—seems already forgotten. The belief of economists in the supremacy of their thinking and the ease with which their absolute claim is accepted today, constitute one of the main obstacles to a systems approach to education and innovation and to the development of inter- and transdisciplinary organization in the education/innovation system.

Most of the current university experiments emerging from the social side of the system, and expressing themselves in Schools of Public Affairs, Public Policy Programs, or Programs in Policy Sciences, constitute essentially *crossdisciplinary approaches.* Instead of one traditional discipline, a group of "soft" disciplines may dominate and provide concepts, principles, and methods which are applied to the entire pragmatic level of the education/innovation system. A good example is Harvard's Program of Graduate Education for Public Service which started in the fall of 1969. It is structured into the four main areas of analytical methods, economic theory, statistical methods, and political analysis, whereby existing "modules" of concepts and methods, mainly pertaining to economics, are employed; not the contents, only the combination is supposed to be new. The implicit assumption here is that a rationale can be found, to which "hard" sciences and technology may be subjected without being part of it. In other words, science and technology are seen as "neutral" tools which may be put to any use, implying also an unbroken faith in sequential problem-solving i.e. a nonsystemic approach. The "seamless web" (Ferkiss, 1969) into which human society has been transformed by technology cannot be grasped in this way.

Policy is an organizing principle at the highest level of planning and

[7] OECD Ministerial Meeting, Paris, 20–22 May 1970; press reports.

[8] The systemic nature of the "technological gap" has been grasped by Peccei (1969).

action[9]; so policy sciences should be in their interaction within the education/innovation system. University programs grouping concepts and methods at the pragmatic level, and imposing a crossdisciplinary claim, should not be called Programs in Policy Sciences, but should be recognized as mere methodological enrichment of political science or economics, both of which can use a much higher degree of rationalization. Policy sciences in educational structures should meet the following "minimum" criteria: (a) they are interdisciplinary and involve the normative level; (b) they are systems-oriented in that the "ethics of whole systems" form their core; and (c) they are design-oriented, not analysis-oriented.

A less pretentious approach is to simply identify methodological approaches involving pluri-, cross-, and interdisciplinary types of cooperation and to teach them as part of a "common language." Courses in forecasting techniques, i.e. in part of the "planning language," have recently been introduced into some universities (see Linstone, 1970). Jones (1970) sees such a common language "through which the diversities of scientific and professional thought can be translated into the language of machines," emerging from the recurrent use of matrix and network notations, probabilistic theory, measurement and performance, and specifications in the place of experienced judgment. Interestingly, he sees such a language forming the basis of "operational sciences" (e.g., materials science, operations research, cybernetics, computer science, systems theory), as well as "operational technologies" (e.g., navigation, military tactics, musical theory, market research, product planning, information retrieval, and systematic design methods) and the applied arts (e.g., basic design, graphic design, industrial design). Ultimately, this observation boils down to the recognition of planning as the "organizing language" at the normative level, through which "operational" (obviously meaning interdisciplinary) coordination of science, technology, and the applied arts is possible. It should also not be overlooked that certain approaches through applied mathematics constitute but a formalization of basic modes of human thinking, independent of systems level and purpose; calling them a "common language" is equivalent to discovering thinking as the organizing principle of the education/innovation system.

The first steps toward a *normative interdisciplinary approach* in the university, i.e. a link between the pragmatic and normative levels in Figure 1, are taken where basic themes of society or need areas are recognized and accepted for a fundamental reorganization of the educational and research disciplines involved. The scientific-technical and the psychosocial

[9] This view is obviously not generally accepted. For the degree of discrepancy in current concepts of policy and policy sciences, see, for example, Dror (1970); Jantsch (1970).

sides of the education/innovation system become integrated in this approach. It is quite obvious that only universities with well-developed structures on both sides can take this approach. The discussion whether universities should deal with technology, or Institutes of Technology should adopt social science—a discussion which, in Europe, is still dominated by a belief in a fundamental polarization between scientific-technical and humanistic cultures (C. P. Snow's "two cultures")—finds its resolution in the normative systems approach. On the other hand, it still presents a hard-to-overcome obstacle on the university's way to interdisciplinarity reaching up to the normative level.

Some university structures, corresponding to this approach, focus on the *educational* function. Significant large-scale examples are:

—The College of Agricultural and Environmental Sciences at the Davis campus of the University of California, organized in five broad areas of systemic nature, including a systems approach to environmental problems.

—The Theme Colleges of Environmental Sciences, Human Biology, Community Sciences, and Creative Communication at the Green Bay campus of the University of Wisconsin, currently geared to undergraduate education, with graduate programs in preparation.

—The Program in Environmental Science and Engineering at the School of Engineering and Applied Sciences of Columbia University.

—The planned graduate College on the Human Environment at the Madison campus of the University of Wisconsin.

—A University of Planning (or Environmental Design) at Solothurn (Switzerland), currently in a preparatory stage.

Other structures focus mainly on *research* and frequently assume the form of interdisciplinary centers in which faculty members and graduate students, pursuing their "formal" careers in traditional departments, may find a "second home." Examples are various urban centers, the Harvard Program on Technology and Science, the Center for Research on Utilization of Scientific Knowledge at the University of Michigan at Ann Arbor, the Center for the Study of Science in Human Affairs at Columbia University, the Center for Integrative Studies at the State University of New York at Binghamton, and the Program of Policy Studies in Science and Technology at George Washington University. A special research domain (*Sonderforschungsbereich*) "Planning and Organization of Sociotechnological Systems" has been proposed in the Federal Republic of Germany, to be established at one or two universities selected for a "focal" approach (most likely at the Technical University, Hanover). The weakness of many of these centers lies in their passive attitudes, which result in their failure to attempt to organize and stimulate research on systemic problems to the degree necessary in view of the complex and interdisciplinary character of such research. To some extent, a certain dominance or even crossdisciplinary claim from the social side may be observed to sneak in, somewhat distorting the original aim.

Of the greatest significance among the steps taken toward normative interdisciplinarity are experimental university programs attempting an *integrated education/research/service approach.* Engineering departments of a conventional type may engage in "technology assessment" (i.e., technological forecasting in a social systems context), as has been done at the University of California at Los Angeles (UCLA). To some extent, Schools or Departments of Architecture, Urban and Regional Planning, or Environmental Design have always been explicitly or implicitly systems-minded, and have developed halfway toward normative interdisciplinarity dealing with important areas of social technology. The Athens Center of Ekistics (Greece), with its international mixture of students, may serve here as a small, but stimulating model of a truly interdisciplinary education/research approach involving the normative level. More broadly oriented experiments include the following ones:

–Specific sociotechnological systems design studies in the framework of the "Special Studies in Systems Engineering" program at the Massachusetts Institute of Technology; Project Metran (an integrated urban transportation system) and the Glideway System Concept (a high-speed interurban transportation system) made considerable impact by stimulating thinking and concrete systems and hardware developments, the latter, for example, in relation to M.I.T.'s Project Transport for a high-speed ground transportation system for the American Northeast Corridor, which became the core of a large decentralized project on a national basis.

–The Program on Science, Technology and Society at Cornell University.

–The Program in Environmental Systems Engineering at the University of Pittsburgh.

–The graduate Program for the Social Application of Technology (PSAT) at the Massachusetts Institute of Technology, planned to start in the fall of 1971.

–The planned Center for Advanced Studies–a Systems Center, an Environmental Center, and an Energy Transformation Center, which may well merge into one–at the Hartford Graduate Center of the Rensselaer Polytechnic Institute.

These experimental structures usually have their own faculty and are started with a view to becoming the core for larger innovative structures. They already include many elements of the function-oriented departments, and to some extent also of the systems design laboratories, proposed in the following section.

On the other hand, the grandiose idea for an international postgraduate "systems university" to be located in Europe—a concept developed by an international committee and subsequently partly through OECD—collapsed because of lack of imagination at the moment when governments, and through them industrial confederations, became involved. The future International Institute for the Management of Technology (IIMT) at Milan (Italy) has now been approved by European governments on the basis of providing a framework for six-week training courses for industrial and public managers.

How do policy sciences fit into this scheme? If a view is adopted that their task is to provide a theoretical and methodological framework for policy formation—defined as the searching for norms and defining of those values which will be more consonant with a dynamically evolving problematic situation (Ozbekhan, 1969)—and its enaction in terms of institutional change (Jantsch, 1970), then *policy sciences constitute an interdisciplinary link between the normative and the purposive levels.* This link corresponds to the feedback link between values and normative planning, between anthropomorphic meaning and social systems design. Such an interdisciplinary link would play a decisive role in shaping a new anthropology dealing with the conditions for action and survival in the industrial and postindustrial societies, a new view of human creativity in the arts as well as in planning, a new understanding of elements entering the guiding images of social policies, from C. G. Jung's archetypal images over explicit values to complex anticipations of the future. It would furnish meaning and criteria to the level of social systems design.

Needless to say, such an interdisciplinary link at the highest level has not yet found an expression in current university experiments. The current struggle for innovation takes place one step down, between the pragmatic and the normative level. Only a number of courses and seminars on values and value dynamics have made a rather modest beginning. To establish policy sciences in the above sense, almost overambitious as it may appear today, is an inevitable step on the way to a transdisciplinary university. But first, the general concept of policy sciences will have to be formulated in these terms, and the current confusion with lower-level concepts of policies *qua* politics ended.

5. A Transdisciplinary Structure for the University

The essential characteristic of a transdisciplinary approach is the coordination of activities at *all* levels of the education/innovation system. Even the more imaginative proposals for new structures and curricular patterns in the university usually stop short of conceiving a coordinated system. Harold Linstone (1970) proposes educational strata of pluridisciplinary internal structure and increasing systemicity to be crossed by students as they advance in their studies; it is then presumably up to the student himself to form his own personal interdisciplinary links. In Hartmut von Hentig's concept (University of Bielefeld, Federal Republic of Germany), much emphasis is placed on the elaboration of pluridisciplinary educational layers as a means to enhance "systems awareness" as well as to maintain a high degree of flexibility in the choice of specialized studies. But the systemic multilevel coordination of educational structures beyond teleological interdisciplinarity (mainly on the scientific-technical side of the system) and some limited experiments in normative interdisciplinarity has hardly been considered so far in the discussions centering around university reform—perhaps because a clear view of the new purpose of the university is still lacking. This section outlines a possible transdisciplinary structure for the university which the author has tried to develop with a view toward the future of the Massachusetts Institute of Technology (Jantsch, 1969b).

The basic structure of the transdisciplinary university may be conceived as being built essentially on the feedback interaction between three types of units, all three of which incorporate their appropriate version of the unified education/research/service function:

—*Systems design laboratories* (in particular, sociotechnological systems design laboratories), bringing together elements of the physical and the social sciences, engineering and management, the life sciences and the humanities, law and policy sciences. Their tasks will not be sharply defined, but rather broad areas will be assigned to them, such as "Ecological Systems in Natural Environments," "Ecological Systems in Man-Made Environments," "Information and Communication Systems," "Transportation/Communication Systems," "Public Health System," "Systems of Urban Living," "Educational Systems," and the like. These broad areas will, and should, overlap. Apart from designing and engineering specific systems, these laboratories will also have the task of long-range forecasting, identifying aspects and boundaries of systems emerging from the simulation of complex dynamic situations. They will be responsible for exploratory and experimental systems building at smaller scale, and they will provide opportunities for a through-flow of professionals for their self-renewal.

—*Function-oriented departments,* taking an outcome-oriented look at the functions technology performs in societal systems, and dealing flexibly with a variety of specific technologies which all might contribute to the same function. Examples of such functions are "Housing," "Urban Transportation," "Power Generation and Transmission," "Automation and Process Control," "Educational Technology," "Telecommunication," "Information Technology," "Food Production and Distribution," etc. These functions are more clearly defined and constitute more stable "modules" than the sociotechnological systems of which they are facets. They constitute need categories which elicit the response of different technological options. Thinking in these categories implies breaking out of the linearity of specific technological development lines, and keeping the view open into a longer-range future. Education in the framework of these systemic functions in society will become ever more relevant, with industry increasingly adopting a corresponding organizational framework (Jantsch, 1968; 1969c). Apart from developing technological options, which come under the heading of these functions, these departments will also emphasize systems analysis of the effects and side effects of selecting specific technologies for satisfying needs in these areas, forecasting which will be more properly technological forecasting in its broad connotation, and assessment of the "systems effectiveness" of technologies in the context of societal systems.

–*Discipline-oriented departments* of a more familiar type, but with a somewhat different scope, comparatively smaller and more sharply focused on the interdisciplinary potential (or "valency") of the disciplines. These departments will be mainly set up in the basic scientific disciplines at the empirical level of the education/innovation system and in the structural sciences, including such new fields as computer science.

The three layers of organizational structure focus on the interdisciplinary coordination of the purposive/normative, normative/pragmatic, and pragmatic/empirical levels of the education/innovation system. The accent is here on the *links between pairs of systems levels*––in other words on *interdisciplinary organizing principles and methods*–rather than on the substance, the accumulated knowledge at the systems levels. Figure 3 shows schematically how the structures of the transdisciplinary university relate to the levels of the education/innovation system.

Unlike present university structures, focusing to an excessive degree on knowledge *per se* and (in the technological disciplines) on "know-how," the function-oriented departments will emphasize "know-what"–the quality which Norbert Wiener has already put before "know-how"–and the systems design laboratories the dynamic "know-where-to," which both are prerequisites for our ambitions to actively shape our future. The discipline-oriented departments on their side will make a new and conscious approach to "know-why" rather than "know-how," emphasizing the investigation of basic potentials and limitations for the design of systems, in particular the "joint systems" of society and technology. This approach may be expected to give an entirely new focus to the life sciences, concerned primarily with the feedback interaction between man and environment.

The feedback interaction between the three types of structural units in the transdisciplinary university is sketched in Table I. It is evident that policy sciences in the "full meaning" outlined in the preceding sections, will

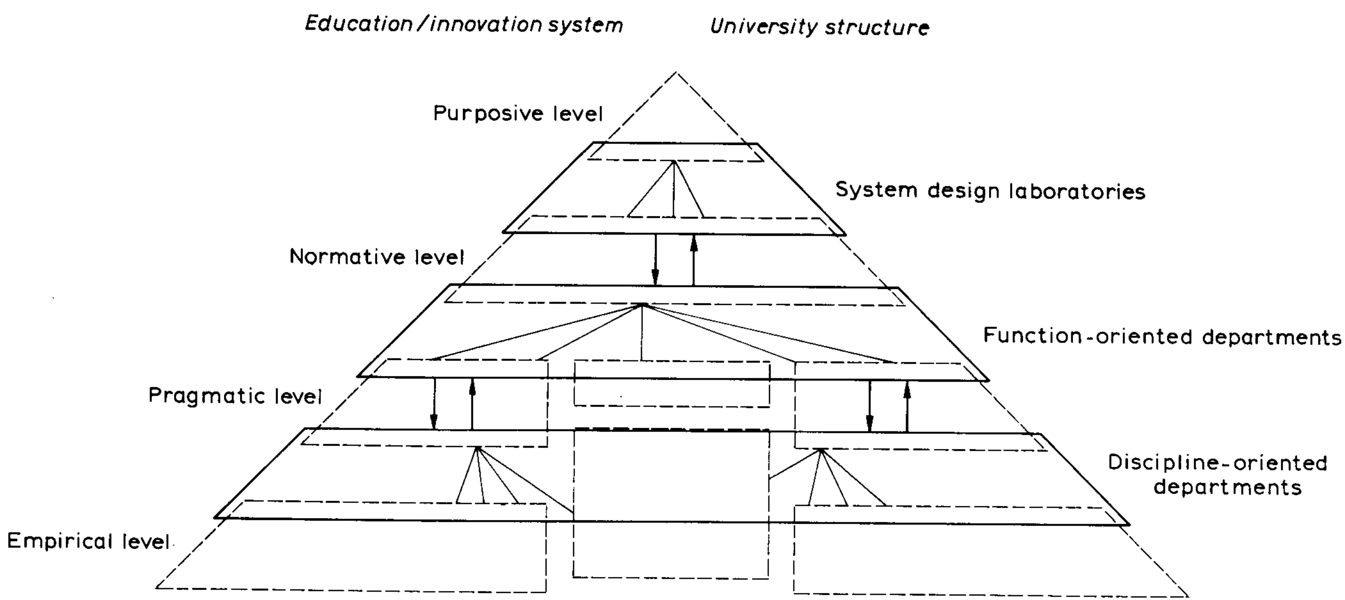

Figure 3. Transdisciplinary university structure. The three types of structural units focus on the interdisciplinary links between the four levels of the education/innovation system ---.

TABLE I

The Pattern of Focal Activities in the Transdisciplinary University
The higher-level activities in this scheme are always carried out through feedback interaction with the lower-placed activities in the vertical columns. All activities are horizontally integrated over the university functions of education, research, and service.

Types of units	Education	Research	Service
Systems Design Laboratories	Sociotechnological systems engineers	Integrative planning and design for "joint systems" of society and technology	"Know-where-to" through inventive contributions to public policy planning and to the active development of new sociotechnological structures
Function-Oriented Departments	Stationary engineers (oriented toward functions and mission for technology, not toward engineering skills or specific technologies)	Strategic planning and development of alternatives (including innovative technological research) in areas defined by functions of technology in a sociotechnological systems context	"Know-what" through providing strategic impulses to the development and introduction of technology into systems of society
Discipline-Oriented Departments	Specialist scientists	Research at the fundamental level, and development of theory	"Know-why" through clarification of the logic principles, basic potentials, and limitations inherent in empirical science

be an important aspect for the work in the systems design laboratories.

We may then envisage a university in which some students go through discipline- and function-oriented departments only, and others go through all three types of structural units. As the latter proceed from undergraduate to graduate and doctoral work they will shift the emphasis of their studies from discipline- and function-oriented departments more and more to the systems design laboratories, at the same time getting increasingly involved with purposeful work in technology and actual sociotechnological systems design and engineering, which will become a full-time (and paid) engagement during the doctoral work. Work phases and "absorptive" phases may alternate, with the need for theoretical learning being enhanced and guided by work. In essence, students will not go through these structural types in sequence, but interact with them simultaneously during their studies.

Such a university will turn out people with a widely varying education, ranging from specialist scientists through mission- and function-oriented scientists and engineers to full-scale sociotechnological systems engineers. The systems design laboratories will also play an important role in the continuous education of professionals, who probably will come back to the university in much greater numbers than today.

One may believe that the outlined three-level structure will give the education function greatly increased flexibility in many respects—for specialized as well as broad (but not superficial) education, for changing tracks, for participation in various actual projects and in various qualities, for combining student and adult education, for stimulating leadership and professionalism, for education geared to various types of careers in the public and private sectors.

An important aspect concerns new dimensions in learning which may be opened up by the change from receiving training to doing useful work. With the university structure outlined here, education will take on more and more the form of self-education, and only part of it with the help of "teachers." A student working in a systems design laboratory will be able to judge for himself what working and learning experience he needs from the function- and discipline-oriented departments, to which he will go back part of his time. He will be able, to a relatively large extent, to work out his curriculum himself, and to set his own educational goals and priorities. Education will move away from the stereotypes of today and become increasingly self-education in an environment which provides an infinite variety of possibilities.

This will be possible, because the student's work can be judged directly from contribution to useful work. He may, therefore, graduate and obtain higher degrees without being examined by the rigors characteristic of the university today. No grading system will be necessary to measure the development of his capabilities. He may not even write a thesis by himself, but make corresponding contributions to team work.

Providing academic careers for all three types of structural units will give immense freedom to the entrepreneurs, and may also change the traditional status system of the university. As a matter of fact, the university professor, as we know him today, may almost vanish, or become almost indistinguishable from the students and professionals, at least in the systems design laboratories and, to some extent, in the function-oriented departments. What we call faculty today, may be the entrepreneurial leaders of the systems design laboratories tomorrow, and the through-flow of younger and older people would be identified today as students moving on in their studies, and professionals moving in and out of the university in their almost continuous education.

Viewed in the light of the research function of the university, the basic form of interaction between the three types of structural units will be a translation process in both directions between the dynamic characteristics of real and "invented" sociotechnological systems, functions and missions for technology, and contributions to them from the scientific disciplines. But the most important task in this process will be the formulation of sociotechnological systems engineering requirements in terms of technological missions and "building blocks." This task will fall primarily to the systems design laboratories.

The enhanced "know-what" will not strangle the freedom of research, but, on the contrary, will give it deeper meaning. The interaction between the three structural levels of the new university may, for the first time, lead to the investigation and *active shaping of science policy* in a rational and systematic (because systemic) way, and to its *planning and implementation in a decentralized way through the university.* This is what is called in this paper the role of the university as a political institution. It will not be easy for the university to maintain its vitality and continuously renew itself in the erosive political process. For the first time, the university will expose itself to full public criticism, and initially suffer considerable shock from the sudden loss of its protection behind the faceless mask of "objective" science. Already the fundamental switch toward broad, horizontal thinking across established disciplines will inevitably lead to a transitory crisis period for the university which has developed its excellence by penetrating deeply into sharply defined, more or less independently pursued disciplines (Stever, 1967). However, there does not seem to be any alternative if a rational, one may even say an ecological, approach to science and technology is considered mandatory, as indeed it has to be in the present situation.

It is obvious that the traditional concepts of "value-free" science and "neutral" technology will become completely dissolved in the unified approach, as the university proceeds to inter- and transdisciplinarity. On the other hand, the normative and psychosocial disciplines also, such as law and sociology, will lose their abstract disciplinary identity and concepts and become aspects of social systems design. Through a transdisciplinary approach, the university will maintain its flexibility also for future situations in which there may be less emphasis on scientific/technical aspects of social systems design, and more on human and psychosocial development. Some people expect such a shift in emphasis to become significant before the end of the century. A more short-range effect of the transdisciplinary university may be renewed "faith" in science and technology and a reversal of the current trend of decreasing interest of students in the scientific/technical side of the education system.

The generalized axiomatics of the transdisciplinary university as it is currently shaping up in a variety of interdisciplinary experiments, develops around what Dubos (1968) calls the "science of humanity," the science of man's total living experience. The transdisciplinary approach thus finding its central theme, which may be understood as the new "universitas," will be humanity-oriented. It will give the university the flexibility to abandon linear organizing principles, such as the current direction and momentum of technology and its supporting sciences.

For the proper study of man, as Carey (1969) sees it, "we need something capable of shaping science goals and strategies with depth and range and visibility . . . a center for examining the interaction of science with higher education, social change, international cooperation, technological development, and economic growth. It would be a center to examine the mix of national investment in science and technology, to assess the quality and social returns of the investment, to identify opportunities and imbalances, to formulate models for investment that are addressed rationally to the variety of needs that we face—in short, . . . a start toward indicative planning of the uses of science and technology."

It is inconceivable that this task be carried out without bringing the full potential of scientific knowledge and ideas, in other words also the potential of the university, into the planning and design process. The university has to become a basic unit in a decentralized, pluralistic process of shaping the national—and, beyond that, a future global—science policy. It has to contribute to the development of a common policy for society at large, participate in the competitive process of formulating strategies, but be fully responsible for its own tactics which include the support of basic science and the development of technological skills.

The institution envisaged by Carey, may be set up as an interuniversity organization, roughly of the type originally conceived for the Institute of Defense Analyses (IDA), which may become the "melting pot" and the center for synthesis of a group of major universities. It would provide a "strategic antenna" oriented toward society's values as well as toward the future and maintain the dialogue with the educated public. It would force government to formulate an overall policy and it would stimulate contributions from the universities backing the institution. It would guide sociotechnological systems design and engineering by giving it the proper framework.

The university will have to maintain close connection with many organizational elements of society, with government at all jurisdictional levels, with research institutes, and with industry. It will stimulate and maintain the information flow in the triangle government-industry-university, and interact actively within this triangle[10] in the planning for society at large. Such

[10] This theme has been elaborated in Jantsch (1967).

interactions may include consortia, joint ventures, prime and subcontracting, consultancies, etc., with government, industry, other universities, and research institutes. The systems design laboratories in the transdisciplinary university will, in many instances, lead this process by developing innovative design proposals.

Conceivably, the university will also provide methodological aid to both government and industry, possibly through broad horizontal institutes, resembling the recently established "Institute for the Future" whose first research center lives in symbiosis with Wesleyan University.

The task of turning the university from a passive servant of various elements of society and of individual and even egoistic ambitions of the members of its community into an active institution in the process of planning for society implies profound change in purpose, thought, institutional and individual behavior. It will give the university freedom, dignity, and significance—qualities which have become grossly distorted in a process in which the university is used, but is not expected and not permitted to participate actively. The thorny way to an inter- and transdisciplinary university has been outlined in this paper as the way to a new and active role of the university in society.

L'UNIVERSITE INTER- ET TRANSDISCIPLINAIRE: LES ASPECTS SYSTEMATIQUES DU PROBLEME DE L'EDUCATION ET DE L'INNOVATION

Résumé

Pour répondre aux sollicitations de son environnement actuel, l'Université devra se donner de nouveaux objectifs en partant du principe qu'il lui faut procurer à la société les moyens d'un renouvellement continu. On peut déduire la structure de l'Université, qui est ainsi exigée, de l'idée d'une liaison intime entre éducation et innovation: aux quatre niveaux à considérer, niveau empirique, niveau pragmatique, niveau des normes et niveau des stratégies. On attend de l'Université que, dépassant les activités multi- ou pluridisciplinaires qui ne se situent qu'à un niveau du système, elle réussisse à élaborer une méthodologie interdisciplinaire lui permettant de relier les différents niveaux et de coordonner d'un bout à l'autre du système les activités conformément à une logique unifiée. En somme, le système d'éducation et d'innovation considéré dans son ensemble pourrait tendre vers le modèle d'un système intégrant hiérarchiquement des niveaux et des objectifs multiples, grâce à une méthodologie transdisciplinaire impliquant le développement d'une logique généralisée et des échanges réciproques entre

l'épistémologie des différentes disciplines. L'article soumet à la discussion les méthodes dont usent aujourd'hui les universités pour établir des liens d'interdisciplinarité entre le niveau pragmatique et le niveau des normes. En conclusion, est présentée une brève esquisse de ce que pourrait être la structure transdisciplinaire de l'Université: trois types d'unités s'y trouvent distingués dans l'organisation, les laboratoires d'élaboration des projets, les départements tournés vers la satisfaction d'une fonction et les départements tournés vers le travail dans une discipline; l'accent y est mis sur la coordination interdisciplinaire dans les trois mises en relation unissant deux à deux chacun des quatre niveaux du système d'éducation et d'innovation, autrement dit, sur la méthode et l'organisation, plus que sur l'accumulation de la connaissance. On fait voir le rôle important qui est réservé aux sciences de la décision dans la mise en relation des deux niveaux supérieurs du système.

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