5. CONCEPT OF AN INTERDISCIPLINARY UNIVERSITY - INTER-TRANSDISCIPLINARITY (Part-1)

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Introduction

This article is an attempt by the author to present to the readers of JEE a brief summary of the report: CERI "Interdisciplinarity - Problems of teaching and research in University, (1970) OECD. This report is based on the results of the seminar on "Interdisciplinarity in Universities "organised by CERI and published by OECD publications. The seminar was held at the University of Nice (France) on September 7th -12th 1970.

The report in the opinion of this author has a great significance for Indian education and its policy makers who are currently grappling with the problem of improving quality of education. The events in India recently which are of great importance are 1) the recommendation of the Yashpal Committee to establish National Commission for Higher Education and Research for rejuvenating the Higher education, 2) In Maharashtra, the State Government appointed a Committee constituted to examine a comprehensive overhaul of Maharashtra State University Act, 1994 and seven other university Acts . 3) The State also proposes to establish a Technical University.

In many discussions and debates, the meaning of the term "University" is taken for granted; also I rarely find any mention of the terms "Interdisciplinarity", which the author considers is of critical importance to consider by all these committees and commissions... Yashpal Committee's report refers only in passing to the importance of learning, instructional design and curriculum design and also institutional planning in Higher education .and the need for dialogue among various disciplines.

Having worked on the theme of quality in the Higher Education system in general and to begin with polytechnic education in particular in TTTIs (now upgraded as National Institute of Technical Teacher Training and Research) for the last 25 years , I am convinced that at the core of all these efforts to improve quality of education at all levels is the understanding and use of following emerging educational disciplines:

1. Theories of Learning (ORMROD J.E. Human Learning, 2008) and (BRANSFORD (Ed) How People Learn 2000)
2. Theories of Knowledge construction (BOWDEN J. and MARTON F. The Universities of Learning 1998)
3. Systems Thinking in Higher education (DALE Et all Human Behaviour and Social Environment, 2009.)

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This CERI report on "Interdisciplinarity" needs to be thoroughly studied to provide context for equipping our teachers in Higher Education with the above mentioned three disciplines. They have the same role to play in the field of education as a whole, which physics, chemistry, and mathematics have to play in the field of developing physical technology. Like engineering. mastering of these three emerging disciplines will help the teachers to study applied disciplines like self- directed learning, educational technology, curriculum design and development and educational institutional planning. These are foundational disciplines for any venture for improving quality of education in general, and particularly higher education including university education.

This article is the summary of ideas debated in the seminar at Nice in France in 1970.. While summarizing I have tried to keep as close as possible to actual terminologies used by various authors in the original report , but at the same time make this presentation as simple as possible for our readers of JEE by reproducing dictionary definitions of certain technical words and giving explanations in the brackets . For those interested in the this theme of "Interdisciplinarity "and the new concept of "Modern university" should study the original report (see reference no 3 at the end of this article)

The whole article is divided into two parts. Part I is summary of ideas presented by one of the authors of the book on "Interdisciplinarity:' Erich Jantsch. Part II gives the summary of ideas on "Interdisciplinary University" authored by Asa Briggs of U. K and Guy Michaud of France.

This is Part I on "Interdisciplinarity". According to Jantsch, the whole world of scientific and technology knowledge is divided into "Disciplines "in its broadest sense. These disciplines are further divided and arranged into various hierarchical levels. (See fig 1 below) and are described as follows:

1. Basic disciplines at the empirical level developed by professional researchers whose aim is to discover "laws of nature"

2. At the next higher" pragmatic" level " the new knowledge is developed by technologists who make use of basic sciences to create products and services needed by the humanity to make life comfortable and thus are able to survive .

3. At a still higher" normative "level, new knowledge is created by the scientists trying to maintain balance between the large socio-technical systems and the natural environmental systems. This effort entails man's active role in shaping his own and the planet's future. In doing so, they attempt to use sciences at the empirical and pragmatic level. to understand the impact of human activities on the natural ecological balance and how to shape his own and planet's future.

4. Still next higher" purposive" level brings into play values and value dynamics (what is worth, desirable as considered by philosophers, artists and religions. In doing so the scientists pick up knowledge from relevant disciplines at empirical, pragmatic, and normative levels. They are in search for ways to know how mankind as a whole can become capable of changing environment by developing education / innovation systems for life long learning.

Jantsch is at pains to convey a message that all sciences have to be used purposefully for improving human conditions. In doing so, scientists operating at each higher level have to employ other sciences at the lower levels in the service of the purposes (axioms) at the higher level. This act of combining sciences at each successive higher level purpose is called "interdisciplinarity". When one reaches the highest "purposive level", he uses interdisciplinary knowledge at all levels below. The purpose at this highest level is to help humanity to cope with ever changing social and

natural environment with the help of education /innovation system. This act of combining the knowledge at all levels is called "transdisciplinarity" This is the job of all national and international universities.

This is a short summary of Part I "Interdisciplinarity" which is now described in detail in this issue of JEE The next issue of JEE Part II will describe how "interdisciplinary universities" who are trying to practice interdisciplinarity are coping with the problems in transforming monodisciplinary nature of the current universities into an interdisciplinary one.

2. Towards Interdisciplnarity and Trans Disciplinarity in Education and Innovation (Erich Jantsch)

Man through science and technology has become "principal cybernetic actor" on our planet . He attempts to create more dynamically evolving ecological configuration and burdens him with the responsibility of setting a purpose.

The crucial question is whether science and its internal structure of relationship is independent of human and social purpose , OR, whether there is a feedback link tying them together . The answer is not only scientific facts and structure can be grasped by the human mind only through anthropomorphic (see dictionary definition at the end of this report) mode of organization.. Also these modes are neither isomorphic(dictionary definition) nor even unambiguous when applied to structure of reality . Modern physics is the creation of anthropomorphic models of "inhuman structure of reality".

The conventional view that the scientists through their research aim to discover natural laws and create knowledge for the knowledge sake and science is a social overhead investment'. These conventional views fail to recognize the need for purposeful linking of science to social purposes.. Today there is purposive science /innovation system .There is a full potential of purposive design of social reality through overall science /innovation system. Earlier attempts were designed to view science as a "value free" abstraction.

There is a feedback relationship between science and social innovations and hence scientific activity should be reorganized with the recognized social goals in the foreground. This reorganization takes place in the form of normative though fragmented interdisciplinary approaches. But in doing so do not forget the "systemic" nature of the social area.

Systems approach as proposed here considers education /innovation system as a general instance of purposeful human activity whose dynamic interaction has come to influence development of the society and its environment. Knowledge would be viewed as a "way of doing", a certain way of managing affairs,

Among other things a new policy and a new structure is expected to emerge from such an approach. University will constitute responses to specific situation the society and science finds itself today. and will be subject to continuous change. The university ought to be designed explicitly with a view to their innate capacity for flexible change in accordance with the dynamically evolving situation. In this science may not play the role it is playing today.

Our dilemma is from whose point of view we try to elucidate the structure of science today: God's or men's. There is no resolution to this dilemma and we have to live with it .We therefore develop a complementary view .

There is no single system of science . There are as many sciences as there are purposes But no single purpose can be assumed to prevail - both in nature's purpose and also in the nature of science and technology, the neutral state would be natural ecology .

Identifying and sketching value base and purpose of system of science is to create anthropomorphic world as general framework of values to be brought into play by identifying

self renewal as the purpose of education and by developing an integrated systems of view of science and innovation.

This is a valid conception of science education and innovation system which nay be relevant to the current dynamic situation of the mankind . This is the fifth biggest threshold in the mankind's psychological evolution. At each of these thresholds, restructuring of overall system of man, society, nature and technology has become necessary to ensure mankind's survival.

Organization for a common purpose means normative and pragmatic principles which is beyond the traditional empirical concept of science. (see fig 1 below).What is important to note is that science has to be recognized as part of social and human organization. The overall systems view will permit us to discuss the role and structure of the university in meaningful terms and to formulate operational concepts of interdisciplinarity and transdisciplinarity as the key notion of the university.

Education for self renewal

We are living in the world of change – both voluntary as well as forced change by mounting pressures beyond our control. But we are learning to distinguish between the two. We engineer change voluntarily by pursuing growth target along the lines of policy and action, but tend to rigidify and preserve structure in our social systems and their institution.. We do not try to change the system themselves. But our conservative linear action for change puts increasing pressure on the structural change in the systems and institutional patterns. Example is the current student's unrest and for the notion that the current type of education may no longer be relevant. We are confused by the degrading effect of technology on the system of human life. in the cities as well as in the natural environment. We are riddled by our decision making process dominated by short range and linear thinking and about piecemeal and passive way engineers and scientists respond to them. This deeply affects university education, research and service functions. Universities enquire new purpose and structures.

The structural change has to be within the university as well as its relations with the society at large and the surrounding community. While society has to change, it is the university which has to change first and lead the process of changing the society .No other institution is qualified and legitimized to do so.

The problems cannot be solved by a single track (discipline) and sequential problem solving approach which is becoming meaningless today. Currently efficient society values nothing more than the "Know how" The task is to build a new society and a new institutions with it. We should take up challenge of restructuring "joint system of society and technology', such as system of urban planning, environmental control and conservation, communication and transport, education and health, information and automation, etc.

The outcome of this battle will depend upon government at all jurisdictional level , industry and the university with the capacity to deal with the systems in an integrated manner cutting across economic, social, political, technological, psychological dimensions. We want education which fosters judgment in complex dynamically, changing situation in all systems mentioned above.

The university should take active role in planning of science and technology in the service of the society. This leadership role demanded of the university is derived from its unique potential for enhancing society's capacity for self renewal. This role pertains to all the three functions of the university, namely, education, research and service. The alarming split in the purpose and operation of the University has blurred the overall purpose of the university.

The new purpose of the university will be to use its unique potential for enhancing society's capacity for continuous self renewal. This new purpose can be broken down in line with the principal characteristics of the society having this capacity :

1. Enhancing pluralism of the society by bringing in creative energies of the scientific and engineering community , as well as of younger students fully into play for the continuous process of self renewal.

2. Improving internal communication by translating into society and the university cultural implications of science and technology on one side and the social objective on the other and by pointing out long range outcome of alternative courses of actions in the context of broadly conceived societal systems

3. Providing positive leadership by working out measures of common objectives and setting out priorities and keeping hopes alive , as well as promoting experiments in societies through ideas and plans and above all by educating leaders of the future.

The university has to be a political institution in the broadest sense, interacting with the governments, industry for planning and design of society's system and in controlling outcomes of introducing technology in the systems. The university must engage in this task as an institution, and not through individual members of its community

University ought to become strategic centre for investigating boundaries and elements of recognized and emerging systems of the society and technology and for working out propositions for planning aimed at the healthy and dynamically stable design of such systems. The new purpose will bring new major changes in the university as under:

1. Principal orientation toward socio- technical system design and engineering at a high level leading to general organizing principle and methods rather than operationalizing knowledge both in education and research

2. Emphasis on purposeful work by students rather than on training.

3. Organization by outcome oriented category rather than inputs of sciences.

With new purpose, the education and research and service function of the university will again be merged and become one. This emerging unity will correspond to an integral view of education /innovation system which will be elaborated later.

Purposive education / innovation system

Education for the self- renewal of the society should become the most important agent of innovation. This is an integral education/ innovation system. According to recent definition: A system is a relationship among objects (specified and defined) in terms of information processing and decision making concepts .

Science and more generally educational sciences become organized in such a system in a particular way which depends upon normative orientation of the education / innovation system. The boundaries of the disciplines, their interfaces and interrelationship no longer correspond to the apriori system of sciences (based on empiricism). Hence we simply speak of s science / education/ innovation system.

View points applied in Fig 1 is that of human systems and its environment. Such an organization is the form of multi-level multi-goal hierarchical system of human activity. Here man has become the chief actor in processing, shaping, and controlling the system. This is an anthropological point of view and this view cannot be objective. Nor would it be possible to form a notion of an integral education system without a purpose and thus dynamically and inherently "subjective view of mind".

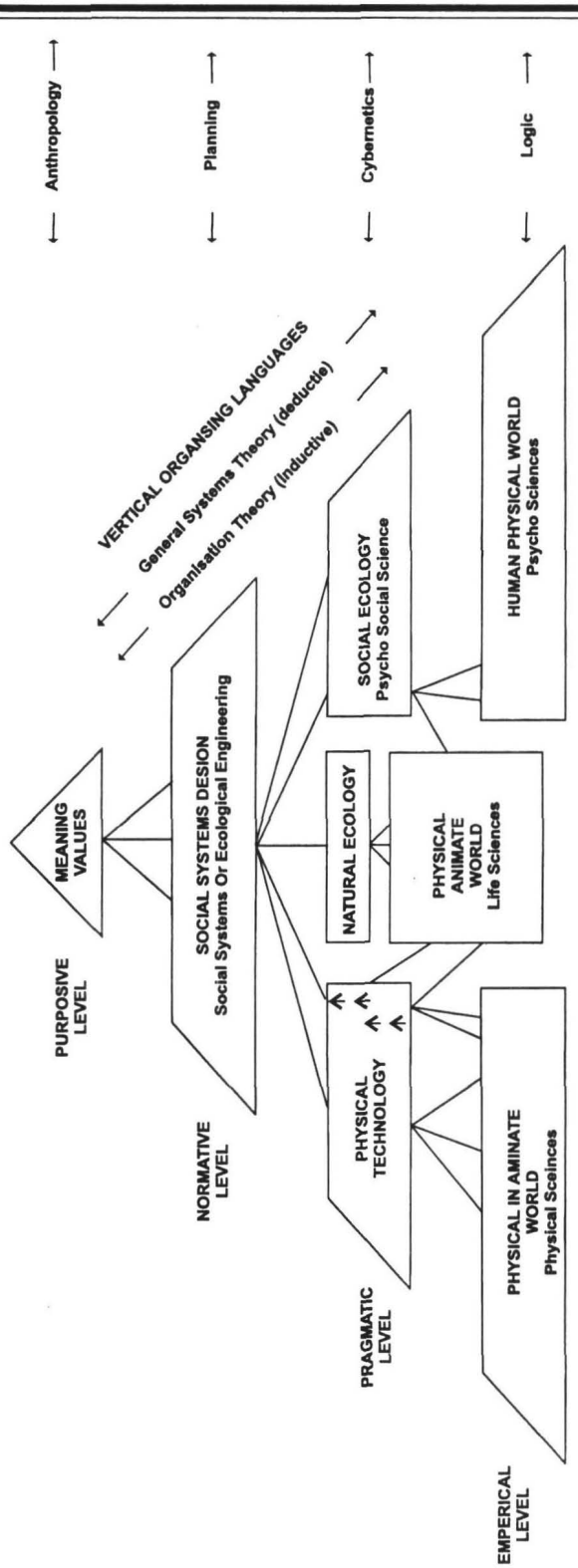


FIG 1 : THE EDUCATION INNOVATION SYSTEM VIEWED AS A MULTI-LEVEL MULTI-GOAL, HIERARCHICAL SYSTEM (Branding lines between levels indicate possible forms of interdisciplinary co-ordination)

The traditional dissection of knowledge and knowledge transfer into a variety of disciplines has been developed from another point of view. That is, it should be possible to arrive at a mechanistic explanation (without the involvement of human mind).of the world "as it is" by putting empirical observations into a logical context. This is only a defective part of social organization. Disciplinarity in science is a static concept which becomes meaningless when considered from the point of view of a "purposive system".

Today, science is considered an integral part of creative human action; the emphasis is shifting to more or less interdisciplinary approaches. But what is interdisciplinarity?

In a purposive education/ innovation system, interdisciplinarity is understood as teleological and normative concept. But what is the purpose? It involves organizing sciences toward an end, that is, linking the adjacent hierarchical levels in the system as sketched in Fig 1 with the aim of coordination. This education/ innovation system assumes specific meaning in terms of systems theory. It is not a stratified system where different strata signify different level of abstraction. Instead of each strata having its own concepts and principles, crossing each stratum downwards will give detailed explanation, while crossing upwards will give the stratum significance. Disciplinary sciences develop in this stratified way.

In a purposive system, interdisciplinarity constitute organizing principles for two levels coordination in terms, concepts and disciplinary configuration. The important notion is that interdisciplinary links between organisational levels, the scientific disciplines defined at these levels change their concepts, structures and aims. They become coordinated through common axioms, a common view point, or a purpose.

The notion of interdisciplinarity can be applied also to subdivisions within the four hierarchical major levels. What is essential is the notion that there is a common axiomatics at the higher level.

The ultimate degree of co ordination in education/ innovation system is called transdisciplinarity and is derived from overall systems purpose and also of the mutual enhancement of epistemology of certain areas called " synepistemic cooperation. With transdisciplinarity the whole education / innovation system would be coordinated as multi-level, multi-goal system embracing a multitude of interdisciplinarity as two level systems, and of course will be modified in the transdisciplinary framework. Also transdisciplinary concepts and principles will change with the change in the overall systems purpose; for example "Notion of progress", "ecological balance", "cyclical development". Thus it requires deeper understanding of the purpose and unambiguous direction for our organisational effort. We must develop values, norms, policy for the mankind to guide education innovation system and focus on the top structure.

Please refer Table-1. on page 37
Successive steps for increasing cooperation and coordination.

In table 1 various steps for coordination and cooperation among disciplines are now defined and at any time have identified organizing principles for hierarchical systems with increasing complexity as proposed in the table 1. It was necessary to introduce new intermediate steps which may be tentatively called cross-disciplinary, and which threatens to blur aim and purposes of in the development toward higher forms of coordination. Most of the so called interdisciplinary instances quoted by universities experimenting with interdisciplinarity are at best cross - disciplinary, or pluridisciplinary (Study table 1 more carefully with this explanation).

Multidisciplinary, pluri, cross-disciplinarity make changes at the same level. It is only with interdisciplinarity and transdisciplinarity, the

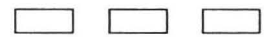
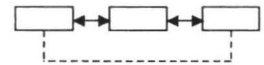
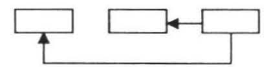
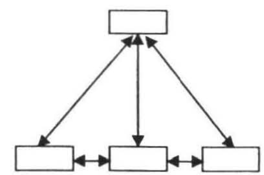
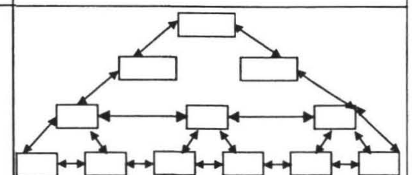
	General Notion	Types of System	System Configurtion
Multidisciplinarity	A variety of discipline offered simultaneously, but without making explicit possible relationship between them	One level multi-goal; no co-operation	
Pluridisciplinarity	The juxtaposition of various disciplines, usually at the same hierarchical level, grouped in such a way as to enhance relationship between them	One level multi-goal; co-operation (but no co-ordination)	
Crossdisciplinarity	The axiomatics of one discipline is imposed upon other disciplines t the same hierarchical level, thereby creating a rigid polarization across disciplines towards a specific disciplinary axiomatics	One level one goal; rigid control from one discipline goal.	
Interdisciplinarity	A common axiomatics for a group of related disciplines id defined at the next hierarchical level, or sub-level, thereby introducing a sense of purpose; teleological discplinarity acts between the empirical and pragmatic levels normative interdisciplinarity between the pragmatic and normative level, purposive interdisciplinarity between normative and purposive level	Two level multi goal; coordination from higher level	
Transdisciplinarity	The coordination of all disciplines and interdisciplines in the education / innovation system on the basis of generalized axiomatics (introduced fro the purposive level down) and and emerging ("synepistemic") pattern	Multi level multi goal; coordination towards a common system purpose	

Table 1: Successive steps for increasing cooperation and coordination in the education / innovation system

education/innovation system becomes alive, in the sense that the disciplinary structures, content and interfaces change continuously with coordination geared to the pursuit of common systems purpose. Interdisciplinarity and transdisciplinarity become key notion for a systems approach to education and innovation.

Education/innovation system is built from the bottom level upwards. In multilevel- mutigoal system, the upper organizational levels cannot achieve anything without the activities at the lower levels. This means there are two major obstacles to achieve interdisciplinarity and transdisciplinarity. One is the rigidity of the disciplines and disciplinary concomitants and axiomatics at the lower levels. The second is the application of lower concepts and axiomatics at the higher level. Both obstacles are severe.

At each level, the organizing language has the quality of an operator in achieving systemic cooperation and coordination. These operators have more anthropomorphic structures (subjective) than as "objective" ones. Let us pursue this subject further on the purposive organization of science .

At empirical level in fig 2, with its logic as its organizing language , science is subdivided into 1) physical sciences , 2) life sciences extending over empirical to pragmatic level , form basic level to complex biological systems and parts of medical technology. 3) psycho-sciences (psychology, behavioural sciences , arts and religion)

These sciences describe the world "as it is". Interdisciplinary coordination is fruitful here particularly between hierarchical level within physical sciences and life sciences, (biochemistry, molecular biology) and life sciences, and psycho sciences.

At pragmatic level with cybernetics, the organizing principle represents higher level of organization .Science is sub-divided into 1) physical technology, Basic technology, of simple technical product to complex technological systems and its functional relationship with social systems.2) more systemic parts of life sciences and natural ecology successfully harnessed in the agricultural technology, 3) Social ecology, culture based psycho-sciences (history , sociology, microeconomics , political sciences , and cultural aspects of anthropology , ethics , social ecology.)

Interdisciplinarity at this level has been interrupted because of the rigidity of the "scientific methods" at the empirical level .was transferred to pragmatic level. Physical technology such as steam engine, steam turbine etc were based on the empirical observations and logical interpretations definitions But as the technologies became complex interdisciplinarity crept in where various physical sciences were combined. For example, in chemical engineering, reactor physics, air craft, rocket design, where complex interactions of micro phenomena were cast into macro phenomenal theories of specific pragmatic applications of technology. .

But such swift adaptation did not take place in social ecology or psychosocial sciences. Hence social sciences lagged behind at the pragmatic level.

At "normative level" with "planning" as the organizing principle deals with social systems design bringing into focus social systems or ecological technology. At its core, is the ethics of the whole systems. It branches out into "social systems technology such as law, macro economics, institutional innovations. It focuses on large social and man/ environment systems and "joint systems of society and technology". Few of these fields have found the valid framework and cannot meet the challenge of interdisciplinarity needed by scientific technological era. It is at the "normative level "a grand conceptualization of man's active role in shaping his own and planet's future is unfolding.

At "purposive" level one brings values and value dynamics into play through interactive fields like philosophy, arts, religion, structuring in an interdisciplinary way some of the fields at "normative level. The organizing language is the "anthropology", the science of how to create an anthropomorphic world and how mankind becomes capable of surviving dynamically changing environment. But psycho-social sciences will have to provide basis for the "new anthropology' through successive interdisciplinary elevation of these concepts.

In fig 2, it is futile to discuss what should be called "science "In the narrow positivistic sense, the notion of science applies to the lowest level in the hierarchy of science in fig 2. Whether this science is organized and coordinated again by science or categories of thought and action which are given other names is matter of arbitrary definition.

What is essential is that interdisciplinarity and transdisciplinarity organization of science is necessary, if education and innovation are to follow the purpose of society's self renewal

To achieve this, the horizontal organizing language(see definitions at the end): logic, cybernetics, planning and anthropology in the order of increasing systemicity intermesh with vertical "organizing language "of general systems theory (deductive) and organization theory (inductive). (Definitions at the end).

If education and innovation is viewed as a purposive system for self renewal of the society we must be able to investigate in a more orderly manner, whether methodologies arising from (horizontal) general systems theory, both of which deal with phenomena that pertains to both groups (anthropology and GST). might not be forged into a methodological structure for 'planning' . With such a structure for 'planning' it will be possible to link the normative, pragmatic and empirical levels in an interdisciplinary way and ultimately aim at transdisciplinary coordination i.e. managing education and /innovation system in an integrated way.

Consequences of not adopting interdisciplinary and transdisciplinary approach.

Today the education function of the university has not been capable of adjusting to the requirement of interdisciplinarity beyond the level of elementary technology (that is, interaction between empirical sciences and pragmatic sciences). To a large extent , education in technology is still categorized in terms of disciplines and dept called mechanical, electrical and chemistry etc .

The grave consequences of not adopting interdisciplinary and transdisciplinary approaches in education are there is a "schism" between education and research functions of the university at the levels of higher interdisciplinary organization. This has created two problems at the level of two complex technical systems.

1. Interdisciplinary research and development is increasingly carried out outside the university structure .Ex . Defense research, space research in America.

2. There is a growing mismatch between engineering education and the requirement of the industry . Industry is reorganizing itself in terms of technological and even socio-technological systems tasks. But education in universities or IITs computer technology is still subsumed under either electrical engineering' or computer science department focusing on product and not on its role in the society. Incapacity of educational structure to adjust to the purposive system of organization (of science). has caused growing 'alienation of students from physical sciences and technological fields .

3. Similarly the sorry state of social sciences will not improve so long as conventional social science departments deal with conventional wisdom of empirical and

behavioural social sciences .

However, there are examples of university programmes geared to integrated study which are paving the way for pragmatic and normative study of social sciences. For example: Themes College of Environmental Sciences, Human Biology, Community Sciences and Creative Communications in University of Wisconsin.

Even more significant will become the influence of system oriented educational and in future research programmes For example: urban, regional and environmental centres, or departments who are expected to create their own approaches to social sciences, if what is readily available is judged to be irrelevant to social systems design.

Today social side of education / innovation system making education relevant to societal problems produces a number of cross-disciplinary approaches (see definitions). All fail to recognize that systemic character of science and technology. Examples are: 1) Management planning and organization-even planning for change is being done in terms of empirical and reductionist concepts of applied behavioural sciences, 2) cross- disciplinary approach is visible in dominant influence of economics over scientific research and development and to education and also to environmental problems and aspects of socio- technical problems systems. Crude economic/ diseconomy concepts are being applied to the above fields, 3) similarly, there is a drastic failure to explain or even describe in disciplinary terms such phenomena like (truly systemic phenomena)

"Technology gap" as economic gap, trade gap market, gap license and royalty gap, management gap, education gap.

The belief of experts in empirical disciplines (economics for example) and the readiness with which their claim are accepted in the materialistic world is the greatest obstacle to systems approach to education/ innovation.

Most of the current emerging university experiments are essentially cross disciplinary in approaches . Examples are school of Public affairs, Public policy programme. The implicit assumption is that in these cross disciplinary approaches a rationale can be found to which 'hard sciences' and technology can be subjected to without being part of it. In other words, science and technology are seen as' neutral tools' which can be put to any use . This also implies unbroken faith in sequential problem-solving . The seamless web into which human society has been transformed by technology cannot be grasped in the way.

3. Structure of the University Practising Transdisciplinarity

The essential characteristics of the transdisciplinary approach are the coordination of activities at all levels of the education innovation system (see fig 2) towards a common purpose.

The basic structure of the transdisciplinarity is conceived as being built on the feedback interaction between three types of units, all three of which incorporate their appropriate version of unified education /research /service function : the three types are 1) system design laboratory, (socio- technical system design lab) 2) function- oriented departments, 3) discipline oriented departments. (see Fig. 3)

1.0 **System design laboratories** (particularly socio- technical system design laboratories). bring together elements of life- sciences and humanities law and political sciences . The tasks broadly assigned to them are: ecological systems in natural environment, ecological systems in manmade-environment, information and communication system, transportation and communication system, public health system, systems of urban living, educational systems and the like These broad areas will and should overlap. Apart from designing engineering specific systems these laboratories will have the task of long rang forecasting, identifying aspects

and boundaries of systems emerging from simulation of complex dynamic situation. They will also be responsible for the exploratory and experimental systems building on a smaller scale and they will provide opportunity for the through-flow of professionals for their self renewal.

2.0 **Function oriented department** which takes an outcome-oriented look at the functions technology performs. In a societal system and dealing flexibly with a variety of technologies which all might contribute to the same purpose.

Examples are : "Housing " Urban distribution", "Automation" Process control" educational technology". Tele-communication", " information technologies", " food production and distribution", etc.

These function/ purposes are clearly defined and are more stable "modules" that socio-technical systems of which they are facets. They constitute need categories which elicit response of different technological options Thinking in terms of these categories means breaking out of linearity of specific technological development lines and keeping the view open toward long range future. Education in terms of these systemic functions in a society will become even more relevant with the industry adopting a corresponding organizing framework. Apart from developing technological functions, these departments will engage in systems analysis of the effects and side effects of selecting specific technologies for satisfying the needs in those areas . Forecasting will be more technological forecasting in its broadest sense and assessment of systems effectiveness in the context of the societal systems .

3.0 **Discipline oriented departments** . These are a more familiar type , but of different scope and comparatively small and sharp focused on disciplinary potential of their disciplines .These departments will be set up in specific scientific disciplines at the empirical level of education/ innovation system and in structural sciences including such fields as computer science .

The three types of organizational structures will focus on interdisciplinary coordination of purposive / normative, normative / pragmatic, and pragmatic / empirical levels of education/ innovation system. The accent here is linking parts of the systems levels i.e interdisciplinary organizing principles and methods , rather than on substance i. e. the accumulated knowledge of the disciplines at the systems levels .

Fig 2 shows schematically how the structures of the transdisciplinary university relate to the levels of the education /innovation systems. Such university will enhance the internal dynamics, the "life" of the system and thus the self- renewal of the society.

Unlike the present university structures which focus excessively on knowledge per se and the technological disciplines on " know how", the function oriented departments. will emphasize "know what" - the quality which is superior to 'know-how'". The system design laboratories will emphasize the dynamics of "know-where-to" both of which are prerequisite to shaping our future . The discipline oriented departments on their side will make new and conscious approach to " know why" rather than " know how " emphasizing the investigation of basic potential to and limitations for the design of systems , in particular joint systems of the society . This approach will give entirely new focus to life sciences in particular , which will then be concerned with the feedback interaction between man and the environment .

The feedback interaction between three types of structural units in the transdisciplinary university is sketched in table 2

As the structures coordinate pairs of systems levels in an interdisciplinary way, they are also coordinated in their work among themselves within system design laboratories leading to function oriented and discipline oriented departments

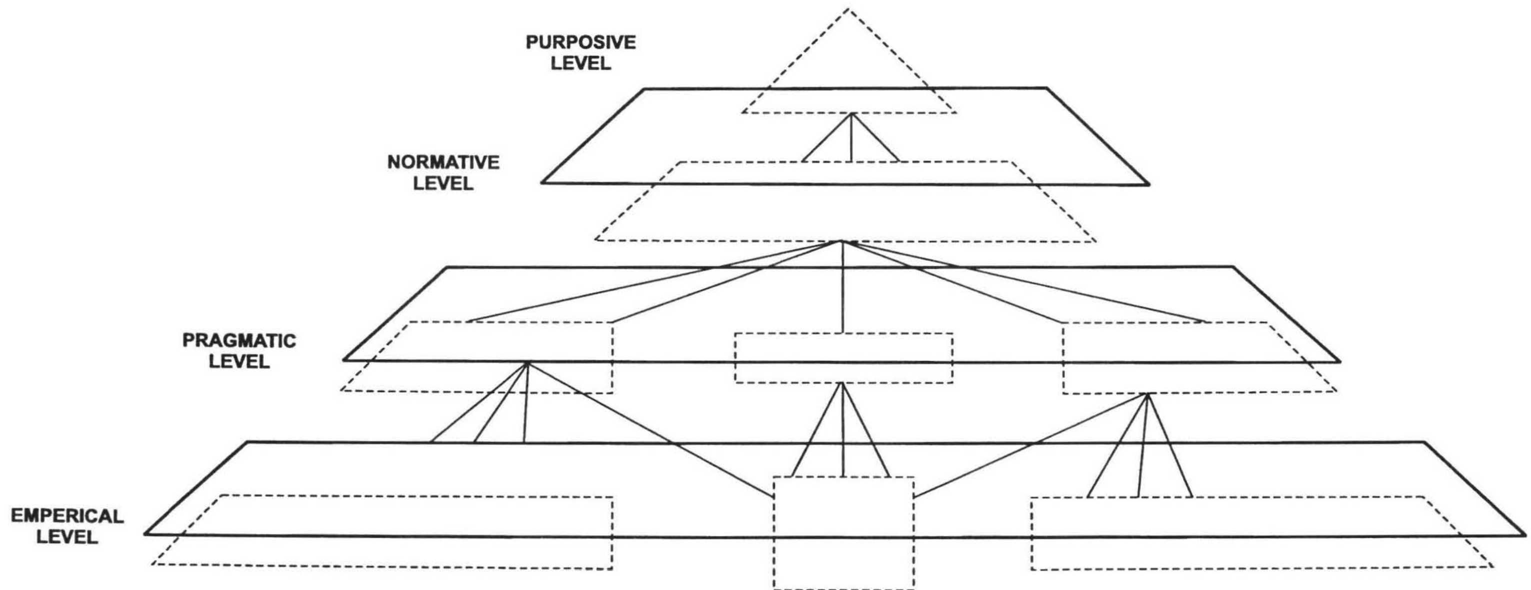


FIG 2 : TRANSDISCIPLINARY UNIVERSITY STRUCTURE
(The three types of structural units focus on the interdisciplinary links between the four levels of the education / innovation system)

	Education	Research	Service
Systems Design Laboratories	Socio-technological Systems engineers	Integrative, planning and design for "Joint system" of society and technology	"Know-where-to" through inventive contributions to public policy planning and to he active development of new socio-technical system structure
Function-oriented departments	Stationary engineers (oriented towards functions and missions of technologies rather than towards specific technologies or scientific technical skills	Strategic planning and development of alternative (including innovative technological research) in areas defined by functions of technology in a socio-technical systems context	"Know-what" through providing strategic impulses to the development of and introduction of technology into system of society.
Discipline-oriented Department	Specialist scientist	Research at the fundamental level and development of theory	"Know-why" through clarification of the logic principles and concepts, as well as the basic potentials and limitations inherent in empirical science.

Table 2: PATTERN OF FOCAL ACTIVITIES IN THE TRANSDICTIONARY UNIVERSITY
(All activities are horizontally integrated and co-coordinated through feedback interaction)

As students flow through within the transcdisciplinary university sketched in table 2, some students go through function and discipline oriented departments only, while others go though all the three types of structural units. As the latter proceed through undergraduate courses to graduate and doctoral courses they will shift emphasis from discipline and function oriented departments to more and more to system design laboratories. At the same time they will increasingly be involved in purposeful work in technology, or social ecology and actual socio - technical design and engineering, which will become full time and paid work. "Work phases" and "absorptive phases" may alternate with the need for theoretical learning being enhanced and guided by practical work . In essence students will not go through structured type sequentially but also interact with them simultaneously.

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

The above three tier structure will give the education function increased flexibility in many respects - for specialized as well as broad based (but not superficial) education for changing tracks , for preparation of actual projects and in various qualities , for combining students and adult education geared to various types of careers in public and private sector.

But there is also a new dimension in learning which may be opened up by the change from receiving training to doing useful work. With the university structure outlined above, the education will be self education and only part of it with take place with the help of teachers. A student working in the system design laboratory will be able to judge for himself what working and learning experiences he will need from the function and discipline oriented departments, he will go back to part time. He will be able to work out his curriculum himself and set his own curriculum goals and priorities. Education will move away from the stereotyped of today to increasingly self education in an environment which provides infinite variety of possibilities.

This is possible because students work will be directly judged from his contribution to useful work. He may, therefore, graduate and obtain higher degree without being examined by rigorous characteristics of the university of today - no grading system, no theses writing - only his contribution the teamwork. Providing careers to the all three types of structural units will give immense freedom to entrepreneurs and may change traditional status system in the university. There will be no distinction between students, professionals and professors, esp in system design laboratories and to some extent function oriented departments.

In the light of research function of the university, the basic form of interaction among three forms of structural intersection : System design laboratories, function oriented and discipline oriented departments will be translational process in both direction between dynamic characteristic of real and "invented" socio-technological systems, function and mission of technology and contributions to them from scientific disciplines The most important task in this process is the formulation of socio-technical systems engineering requirement in terms of their technological missions and building blocks and this task will fall to the systems design laboratories The concept of " value free science" and "neutral technology" will be completely dissolved in the systems approach as the university proceeds towards interdisciplinarity and transdisciplinarity.. On the other hand, normative and the psychosocial disciplines such as law and sociology will lose its abstract disciplinary identity and concepts

will become social systems design. Through transdisciplinary approach the university will also maintain its flexibility for the future situations with less emphasis on scientific and / technical aspects of social systems design and more on human and psychological development With transdisciplinarity there will be renewed faith in science and technology and renewal of interest of students in the scientific and technical side of education system. The generalized axiomatics of transdisciplinarity as it is shaping up in variety of interdisciplinary experiments will develop around "science of humanity – the science of man's total living experiences. The new university will be oriented toward humanity. The University will now be more flexible and will abandon linear organizing principle now underlying current direction and momentum of technology and its supporting sciences.

The enhanced "know- what" will not strangle the freedom of education and research , but will give deeper meaning to education and research. It will help the university to assume a role of a "political institution", because the university will actually shape the science policy- a rational and systemic way and to planning and implementation in a decentralized way. For the first time the university will expose itself to public criticism. It will be a cultural shock to the university on its loss of "protected status" obtained through faceless mask of " objective science " The fundamental switch towards broad horizontal thinking across disciplines will lead to the transitional crisis period for the university, by penetrating deeply in the sharply defined more or less independently pursued disciplines. There is however no alternative to the ecological approach to science and technology in the present condition.

It will be to have interuniversity organization to become a melting pot and a centre for synthesis of major group of major universities. It would provide "strategic antenna" oriented toward society's values and its future. This would maintain dialogue with educated public, help government form overall policies; stimulate socio-technical system design and engineering, develop close ties with the organizational elements of the society, i.e. government, research institutes and industry, play an active role providing new systems "check and balances" for the ideas and plans. The university will maintain the Government – university-industry triangle and will interact within this triangle actively in planning for the society at large. The system design laboratories will lead to the process by delivering innovative design proposals.

An economic base will have to be provided for this type of interaction of the university leading to enabling university to earn its own income and thereby gain independence.

Turn university from its passive role as servant of various elements of the society and ambitions of individuals of the community INTO an active institution participating in the process of planning for the society. This task involves profound changes in the purpose and thought as well as institutional and individual behaviours. But it will give university freedom, dignity and significance. Universities will have to adopt the thorny path to inter/ transdisciplinarity as a way to assume an active role in the society.

The foregoing sections explained Erich Jantsch's ideas about how the world of science and the university can be transformed to achieve interdisciplinarity in order to deal with society's real problems through active interaction.

The next part written by Asa Briggs and Guy Michaud deals with rearrangement of research, education and service functions of the transdisciplinary university through reform in external and internal patterns, curricular reforms, reforms in teaching methods and finally teacher training.

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Definitions of Key Words

(In the order of appearance in the article)

Ecology: The Branch of Biology which deals with relations of organisms with Physical surroundings.

Anthropomorphic mode: All attributes of the humans form to God, animal or things

Isomorphic: Exactly having the same from.

Anthropology: Study of human civilization

Axiomatics: 1 Accepted or widely accepted principle 2. Self evident truth

Ethics: A set of moral principles

Horizontal Language: They are languages employed to organize content of all disciplines in the same stratum; for example logic at the empirical level, anthropology at the purposive level. They intermesh with the vertical organizing languages of "general systems theory" (deductive) and "organization theory" (inductive)

Vertical Language: Are the systems language and organization theory, Systems theory combines bits and pieces of information at each. Organization thoery level (incomplete se Edgar schein)

Dialecties: The art of investingating the truth of opinions, logical disputations.

Cybernetics: The science of communication and control in both machines, and living things.

Metamorphosis: The change of form by natural or supernatural means.

Normative: Establishing a norm; (standard pattern of behaviour)

Pragmatic: Dealing with matters relating to paractical requirement, or consequences

Technology: Study and use of mechanical arts and applied sciences

Evolution: 1. Gradual development from simple to complex form 2. process by which species develop from earlier form to more complex form as an explanation of its origin.

Disciplinarity: It is the specialized exploration of a given homogenous subject matter producing new knowledge and making obsolete old knowledge. Disciplinary activity results in incessantly formulating and reformulating of the present body of knowledge about the subject matter Following seven criterion levels distnguish on discipline from the other.

1. Material field of the discipline, 2. the 'subject matter' of the discipline, 3. The 'level of theoretical integration' of a Discipline, 4. The 'methods of the discipline', 5. The 'analytical tool of the discipline', 6. Application of the discipline in the field of practice, 7. Historical contingencies of the disciplines

Pluralism: a) A theory or a system of devolution and autonomy for the individual bodies in preference to the monolithic state control. b) A form of society in which members of minority communities maintain their independent cultural traditions.

Empirical: 1. based on or acting on observation or experimentation, and not on theory 2. regarding sense data as valid information. 3. deriving knowledge from experience alone.

Empiricism: The theory that all knowledge is derived form sense experience.

Purposive: Having or serving a purpose

Purposeful: Indicating purpose, intentional

Innovation: Bringing new ideas and methods in the exiting system.

Invention: create by thought a devise; originate new method and instrument.

Function: Mode of activities by which a thing fulfills its purpose.

Functional: Serving a purpose.

Functionalism: It is a belief or stress on practical appication of a thing

Politics: A science of government; activities concerned with acquisition or execution of authority or governance.

Politics: A science of government; activities concerned with acquisition or execution of authority of governance.

Political: Concerning state, government, or public affair

Cooperation: Process of working together for the same end

Coordination: Process of bringing together various parts and movements into a required relations to ensure harmony, or effective relations.

Adaption: The act of adjusting i.e. the process of organism or species become suited to the environment

Value: It is the worth, desirability, or utility of things or quality on which it depends.

Social Science: Scientific study of human society and social relationships.

Social: Relating to society or its organization.

Organization: The act of giving orderly structure

Social side of Education: Making education relevant to the social problems

Linearity in development: Involving only one dimesion in the development; Progressing in a single series of steps which is different from systemic development.

Profession: Calling and vocation, ESP one that involves one branch of advanced learning or science.

Open System: It means that any system id dynamically connected to the environment of which they are part. It means that an ongoing exchange exists between the subject system and the environment

Demography: The study of statistics of birth, death, disease as illustrating the conditions of life in the community.

Vocation: Persons employmnt regarded as requiring dedication; trade, or profession.

Department: A branch of study iwth and its administration at the university, school etc.

School: A branch of study with separate examination in the university, deparment, and faculty (Ex: History school).

Organizing Languages For: Interdisciplinary coordination and transdisciplinary coordination the author uses two sets of organizaing languages one is the vertical organizing language, "General systems theory and the seconed on is "horizontal organization theory"

General Systems theory (Dale, Smith ET all 2009) (GST)

GST is the theory of order. It is the science of "wholeness". It postulates the growth and change in liging organisms occurs due to relationship and interactions among the individual parts comprising the organism. GST formulates principle of organization in the universe right from an atom to the organization quality of the universe. And also to all those who study human behaviour, from psychologists to suicidal scientists. This premise of the GST is also applicable to scientific method. Scientific method applied to in animate things adopt the principle of "reductionism". I this the scentists reduces a complex subject matter by reducing it to simple and manageable parts and conducts scientific investigation to discover natural laws. This method has lead to the fragmentation of

knowledge which is divided now into disciplines.

In the study of animate being and especially human beings, systems theorists found that such a fragmentation is harmful.

An individual and the social organization they join are now viewed as a whole. By not looking at its individual parts, but at the relationship among these parts.

A social organization exhibits features of general order and features that are distinctive to humans as species implicit in this notion is a hierarchy of wholes, each higher level has an ordering that is chracteristic of lower levels and other features that are characteristics that are distinctive to higher levels. The concepts that have their origin in general order are: Emergence which means that the whole possesses open systems which suggest that the systmes are dynamically connected to its surrounding environments. Entropy is a measure of disorder. Which is true of all physical inanimate things? But humans and in general all living organisms a process of ordering and not disordering exists. Thus all forms of social organizations have potential for growth. Steady state is yet another property in which a social organization maintains favourable balance of input and output to remain healthy Equifinality and Holon are the two remaining properties of general order.

DST has been used by Jantsch in his article for explaining organization of science by another social organization called community of scientists, into hierarchy of sciences (in abroad sense). This hierarchy ranges from empirical level, pragmatic level, normative to purposive level. Education / innovation system at its apex level. Each higher level orders lower levels of sciences through inter and transdiciplinarity using the language of vertical general system theory.

Horizontal Organization Theory: This theory states that planned coordination of the activities of a number of people for achievement of purpose or goals through division of labor and functions through hierarchy of authority and responsibility. (Edgar Schein: organizational psychology, 1983).

When related to the organization of science, the scientific community achieves the objective of developing unified knowledge of science by dividing its labour at four levels: emirical, pragmatic, normative and purposive. At each level the scientists have a specific function of at empirical level, they adopt a positivist stance and assume that truth exists "out there" and conduct experiments to ascertain truth by hypothesis testing and organize knowledge by using 'Logic' as the organizing language., At each higher level, every scientific community adopts a particular methodology and adopts "cybernetic" at the pragmatic level, planning at the normative level, and anthropology at the purposive levels. It then achieves planned coordination of activities in an interdisciplinary manner and ultimately in a transdisciplinary manner by employing a purpose / axioms at the higher level for such a linking .

To sum up, GST emphasizing wholeness of the scientific endeavor, organization theory explains how scientific community achieves this wholeness through planned coordinated efforts at each successive level of four levels of the scientific activities.