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9. ABSTRACT

Major points emphasized in this study: a nation or society should be analyzed as a social system, a system in constant change; the entire communication needs of a society should be studied before determining the best way to use instructional media; planning for the employment of instructional technology should be based on interdisciplinary research; a unitary conceptual scheme is essential if interdisciplinary research and application are to be integrated--a general theory of the nature of living systems and how to analyze them. Guidelines and assistance to less developed countries are proposed for choosing, planning and implementing national and instructional communication systems for effectively implementing educational and other social development programs. Methodology for deciding among alternatives has not yet matured, but widespread consensus is arising about its essential.

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Alternative Communications Systems for Education in the Less Developed Countries

James G. Miller

Report Number Three
1973

This report has been prepared by the Academy for Educational Development under Contract No. AID/csd-2829 for the Office of Education and Human Resources, Bureau for Technical Assistance, Agency for International Development.

Section 220 of the Foreign Assistance Act of 1970 directs the U.S. Agency for International Development to undertake a wide array of activities aimed at assisting the developing countries in their use of communications technologies for education, agriculture, health, and community development. The technologies consist of radio, television, programmed teaching systems, computers, and communications satellites.

To carry out some of the activities mandated under Section 220, AID has contracted with the Academy for Educational Development to direct scientific research on the use of educational technology. to assess educational effectiveness and cost implications of various alternative communications systems, and to develop ways of applying electronic communications systems to agriculture, nutrition, population, and community development.

This report is one of a series prepared by the Academy and its subcontractors for AID under the terms of the contract. The reports in this series include:

1. Research and Development Priorities in Instructional Technologies for the Less Developed Countries
2. Research and Development Priorities in Instructional Technologies for the Less Developed Countries: A Summary
3. Alternative Communications Systems for Education in the Less Developed Countries
4. Broadcast Satellites for Educational Development: Possible Key Policy Decision Points, 1973-1978
5. Broadcast Satellites for Educational Development: The Experiments in Brazil, India, and the United States
6. Strategies for the Use of Mass Communications Media in the Technologically Developing Nations: Basic Education, Family Planning, and Nutrition
7. Communication Strategies for Agricultural Development
8. Communication Strategies for Development: A Summary
9. Technical-Economic Considerations in Public Service Broadcast Communications for Developing Countries

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Introduction

In 1971 UNESCO, with the assistance of an international panel of consultants, outlined a proposed international program of communication research. Their statement includes the following paragraphs. They sketch out a constructive approach to the topic of this present document--how a less developed nation should select among alternative strategies for using instructional technologies in its educational system:[1]

"In order that the new communication technologies can 'fit into society,' can be functional within it, and that policy making and planning can reflect the needs of people, much more multidisciplinary research is required. New 'models' for communication patterns must be produced in which the operation of inter-personal communication systems are combined with modern media structures to give a much more complete picture of how communication and diffusion of different types of information really takes place.

"To give one example of the sort of question which might well be examined by such multidisciplinary study: in a society of strong oral tradition (such as many in Africa) what is the influence of this tradition on existing communication structures, how do the media fit into this tradition, have the form and content of the media taken account of it and is the existence of the media changing the tradition and altering the communication structure. (It is only by answering such questions as these that a style of radio broadcasting which is anything but imported can be developed.)

"Every society has an indigenous culture, the values of which should be given prime consideration in planning for national development. But culture is not static or simply a remnant of the traditional past. Present patterns must be studied in relationship both to the historical past and the technological future.

"There is another important viewpoint to this research question of the analysis of communication needs. This looks at the problem from the other direction to ascertain the communication components in all aspects of national development plans and programmes. This approach involves a general survey of all sectors of the national development plan, including both the public and private sectors of the economy, and analysing the need for all forms of communication in order that the plan can be carried out.

"Development plans are usually broken down into programmes and projects. These should be examined in detail and the project 'support' communication requirements noted. From the various parts of the plan (e.g. agriculture, housing, transportation, health, culture, education, industry, etc.) should be extracted in quantifiable terms all requirements for communication performance...different aspects of communications technology (radio; television; telex; and the electronic dissemination of printed information) in education (primary and secondary schools; intramural and extramural higher education; teacher training and in-service upgrading; rural adult education, vocational orientation, provision of cultural, civic and educational climate for development) to highlight the critical issues which would determine the formulation

of alternative courses of action. These determining issues themselves could be seen to entail a series of choices between alternatives--national or regional autonomy; lingua franca or local dialects; centralized or local media production; priority investment in radio or television; terrestrial or satellite telecommunication; rural or urban development; medium wave or tropical band propagation; construction of new networks or refurbishing of old ones to make them functional; direct teaching or participation in learning; etc. Permutations of these (and many others) on the basis of systematic analysis of information provided by a comprehensive research programme could enable [a country] to design a number of possible alternative comprehensive strategies (education/communication models) from which to choose those which offer the most productive solutions to educational development problems.

"Often, whenever new strategies are advocated, experimental micro-projects will be required to determine by research the relative effectiveness of each of a number of possible approaches. Research is the most important aspect of such pilot projects and should involve an overall critical analysis of all stages of the design, development, operation and follow-up of the projects. It should not only seek to prove intended effectiveness but should also anticipate and identify unintended effects. Within this process of design on the basis of such research, alternative models, programmes and projects can be minutely analysed in terms of their requirements for personnel, hardware, finance, training, research, etc. This comparable data can then be one basis of choice between alternative strategies for communication development.

"A comprehensive and valid methodology for the decision-making involved in communication planning has yet to be devised. However, some of the initial tasks necessary to the formulation of the theoretical model for it are at present being undertaken on a limited scale. The method will grow from a systematic programme of research into the effectiveness and effects of communication media, the critical analysis of national policies for communication, and scientific studies of the economics of communication in national development.

"Probably the key to decision-making and choice of alternatives could be seen to lie in a systematic evaluation of innovations according to a number of relevance factors--economic, social, educational, cultural, political, technological--based upon weightings ascribed by factual information acquired in previous stages of the planning process (above).

"To provide one example: a recent study undertaken at the request of the Government of India by UNESCO in association with FAO and WHO and in consultation with ITU has pointed out the facts (among many others) that while a communication system for family planning information, directed to groups of health educators, based on television, might be highly relevant in the educational and social contexts, the economic relevance factor was not so favourable to the use of television for this purpose. In contrast, the same medium as part of a national system directed to teaching mathematics and science to secondary school pupils was highly relevant on the social, educational, technological and economic scales of judgement. Again,

health education to women's groups in urban areas and an agricultural extension system assisted by television to farmer groups engaged in coming to terms with the 'green revolution' in certain rural areas of high population density were seen to be 'multi-relevant' only when local broadcasting ensured that programmes were culturally appropriate. These sorts of knowledge, based upon co-ordinated research and co-operative action, are required by the development planners for them to make valid choices for investment and action. Such data can only be collected and correlated through an interdisciplinary effort such as the Indian team of experts effected.

"The allocation of relevance weightings in the example quoted had, in the main, to be based upon subjective value judgements. Planners need from communication researchers much more objective, scientific bases for pinpointing the comparative efficiency and effectiveness of the alternative means of solving communication problems.

"In the long-term, the only possible approach may well be the application of systems analysis techniques. The application of these to assisting in the solving of communication problems in developing countries must now be the subject of concentrated research. But, a warning--in considering the application of systems analysis, it would be disastrous for communications development planning if the bias of the computer toward readily quantifiable information were to lead to similar bias in the systems analysis. Moral values, social and traditional considerations must not be slighted in the <u>process</u> of decision-making for development....

"As the implementation of plans and programmes takes place, there will be need for constant evaluation and assessment of operational processes and effects. The phasing of the overall development of communication systems will also be a continuous task, matching it to the needs as assumed under present and future national policy. Such national policy itself will necessarily be re-evaluated and re-assessed by other researchers and planners. The role of the suggested institutionalized communication policy council will, therefore, have to be a continuing one as watchdog, as adviser and as co-ordinator within the broader framework of national development policy, undertaking to continue the constant critical analyses of the meaning of <u>communication in society</u>."

The foregoing statement expounds a philosophy that will be expanded upon in the following chapters. Several major points in it which we shall emphasize are: a nation or society should be analyzed as a social system, a system in constant change; the entire communication needs of a society should be studied before determining the best way to use instructional media; planning for the employment of instructional technology should be based on interdisciplinary research; a unitary conceptual scheme is essential if interdisciplinary research and application are to be integrated--a general theory of the nature of living systems and how to analyze them.

We have recently written a monograph presenting an extensive research program for instructional technologies in less developed nations.[2] This monograph indicates how such research can be applied in the selection of the optimal systems of instructional technologies in such countries. Our exposition covers the following major points:

- First a conceptual system is outlined which is designed to integrate the theory and research of several mathematical, biological, psychological, social, and engineering disciplines concerned with living systems. The general outline of the systems approach is certainly familiar to many readers, but a general approach is not enough to provide precision of method in the selection among alternative instructional strategies. A brief summary of relevant aspects of much more extensive work by the author is therefore presented to orient readers unfamiliar with it to the specific approach to be followed in later chapters.

- After that the various living systems involved in education are described.

- Then the various media, all-human, all-hardware, and mixed are listed which should be considered by less developed nations planning to use instructional technology. The characteristics of each are described.

- Then the various ways of determining the costs of instruction are discussed.

- Then the various ways of determining the effectiveness of instructional hardware from an engineering point of view are described.

- Then the ways of determining the educational effectiveness of any instructional process are described.
- And finally the procedure for making the final choice among alternative instructional systems is presented, taking into consideration not only technical findings but also social, cultural, economic, and political issues.

Notes and References

1. Anon. Proposals for an International Programme of Communication Research. COM/MD/20. Paris: UNESCO, 10 September 1971 (mimeographed).

2. Miller, J. G. Research and Development Priorities in Instructional Technologies for the Less Developed Countries. Washington, D.C.: Academy for Educational Development, 1973.

CHAPTER I

THE NATURE OF LIVING SYSTEMS*

General systems theory is a set of related definitions, assumptions, and propositions which deal with reality as an integrated hierarchy of organizations of matter and energy. General systems behavior theory is concerned with a special subset of all systems, the living ones.

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* This chapter is a summary of a conceptual statement published as Miller, J.G. Living Systems: basic concepts. Behav. Sci., 1965, 10, 193-237. See also Living systems: structure and process. Behav. Sci., 1965, 10, 337-379; Living systems: cross-level hypotheses. Behav. Sci., 1965, 10, 380-411; Living systems: the cell. Currents in Mod. Biol., 1971, 4, 78-206; Living systems: the organ. Currents in Mod. Biol., 1971, 4, 207-256; Living systems: the organism. Quart. Rev. Biol., 1973, 48, 2, 92-276; Living systems: the group. Behav. Sci., 1971, 16, 302-298; Living systems: the organization. Behav. Sci., 1972, 17, 1-182.

1. Matter and Energy

Matter is anything which has mass (m) and occupies physical space. Energy (E) is defined in physics as the ability to do work. The principle of the conservation of energy states that energy can be neither created nor destroyed in the universe, but it may be converted from one form to another, including the energy equivalent of rest-mass. Matter may have (a) kinetic energy, when it is moving and exerts a force on other matter; (b) potential energy, because of its position in a gravitational field; or (c) rest-mass energy, which is the energy that would be released if mass were converted into the other in accordance with the relation that rest-mass energy is equal to the mass times the square of the velocity of light. Because of the known relationship between matter and energy, throughout the report the joint term matter-energy is used except where one or the other is specifically intended. Living systems require matter-energy, needing specific types of it, in adequate amounts. Heat, light, water, minerals, vitamins, foods, fuels, and raw materials of various kinds, for instance, may be required. Any change of state of matter-energy or its movement over space, from one point to another, is action. It is one form of process.

2. Information

Throughout this presentation information (H) will be used in the technical sense first suggested by Hartley in 1928.[1] Later it was developed by Shannon in his mathematical theory of communication.[2] It is not the same thing as meaning or quite the same as information as we usually

understand it. Meaning is the significance of information to a system which processes it: it constitutes a change in that system's processes elicited by the information, often resulting from associations made to it on previous experience with it. Information is a simpler concept: the degrees of freedom that exist in a given situation to choose among signals, symbols, messages, or patterns to be transmitted. The total of all these possible categories (the alphabet) is called the ensemble. The amount of information is measured by the binary digit, or bit of information. It is the amount of information which relieves the uncertainty when the outcome of a situation with two equally likely alternatives is known. Legend says the American Revolution was begun by a signal to Paul Revere from Old North Church steeple. It could have been either one or two lights "one if by land or two if by sea." If the alternatives were equally probable, the signal conveyed only one bit of information, resolving the uncertainty in a binary choice. But it carried a vast amount of meaning, meaning which must be measured by other sorts of units than bits.

The term marker refers to those observable bundles, units, or changes of matter-energy whose patterning bears or conveys the informational symbols from the ensemble or repertoire.[3] These might be the stones of Hammurabi's day which bore cuneiform writing, parchments, writing paper, Indians' smoke signals, a door key with notches, punched cards, paper or magnetic tape, a computer's magnetized ferrite core memory, an arrangement of nucleotides in a DNA molecule, the molecular structure of a hormone, pulses on a

telegraph wire, or waves emanating from a radio station. The marker may be static, as in a book or in a computer's memory. Communication of any sort, however, requires that the marker move in space, from the transmitting system to the receiving system, and this movement follows the same physical laws as the movement of any other sort of matter-energy. The advance of communication technology over the years has been in the direction of decreasing the matter-energy costs of storing and transmitting the markers which bear information. The efficiency of information processing can be increased by lessening the mass of the markers, making them smaller so they can be stored more compactly and transmitted more rapidly and cheaply. Over the centuries engineering progress has altered the mode in markers from stones bearing cuneiform to magnetic tape bearing electrons, and clearly some limit is being approached.

In recent years systems theorists have been fascinated by the new ways to study and measure information flows, but matter-energy flows are equally important. Systems theory deals both with information theory and with energetics--such matters as the muscular movements of people, the flow of raw materials through societies, or the utilization of energy by brain cells.

It was noted above that the movement of matter-energy over space, <u>action</u>, is one form of process. Another form of process is information processing or <u>communication</u>, which is the change of information from one state to another or its movement from one point to another over space. Communications, while being processed, are often shifted from one matter-energy state to another, from one sort of marker to another. If the form or

pattern of the signal remains relatively constant during these changes, the information is not lost. For instance, it is now possible to take a chest X ray, storing the information on photographic film; then a photoscanner can pass over the film line by line, from top to bottom, converting the signals to pulses in an electrical current which represent bits; then those bits can be stored in the core memory of a computer; then those bits can be processed by the computer so that contrasts in the picture pattern can be systematically increased; then the resultant altered patterns can be printed out on a cathode ray tube and photographed. The pattern of the chest structures, the information, modified for easier interpretation, has remained largely invariant throughout all this processing from one sort of marker to another. Similar transformations go on in living systems.

One basic reason why communication is of fundamental importance is that information patterns can be processed over space and the local matter-energy at the receiving point can be organized to conform to, or comply with, this information. As already stated, if the information is conveyed on a relatively small, light, and compact marker, little energy is required for this process. Thus it is a much more efficient way to accomplish the result than to move the entire amount of matter-energy, organized as desired, from the location of the transmitter to that of the receiver. This is the secret of success of the delivery of "flowers by telegraph." It takes much less time and human effort to send a telegram from one city to another requesting a florist in the latter place to deliver flowers locally, than it would to drive or fly with the flowers from the former city to the latter. Also it may turn out to be the secret of successful education at a distance.

Shannon was concerned with mathematical statements describing the transmission of information in the form of signals or messages from a transmitter or a receiver over a channel such as a telephone wire or a radio band.[4] These channels always contain a certain amount of noise. In order to convey a message, signals in channels must be patterned and must stand out recognizably above the background noise.

Matter-energy and information always flow together. Information is always borne on a marker. Conversely there is no regular movement in a system unless there is a difference in potential between two points, which is negative entropy or information. Which aspect of the transmission is most important depends upon how it is handled by the receiver. If the receiver responds primarily to the material or energic aspect, it is a matter-energy transmission; if the response is primarily to the information, it is an information transmission. For example, the banana eaten by a monkey is a nonrandom arrangement of specific molecules, and thus has its informational aspect, but its use to the monkey is chiefly to increase the energy available to him. So it is an energy transmission. The energic character of the signal light that tells him to depress the level which will give him a banana is less important than the fact that the light is part of a nonrandom, patterned organization which conveys information to him. So it is an information transmission. Moreover, just as living systems must have specific forms of matter-energy, so they must have specific patterns of information. For example, some species of animals do not develop normally unless they have appropriate information inputs in infancy. As Harlow showed, for instance, monkeys cannot

make proper social adjustments unless they interact with other monkeys during a period between the third and sixth months of their lives.[5]

3. System

The term system has a number of meanings. There are systems of numbers and of equations, systems of value and of thought, systems of law, solar systems, organic systems, management systems, command and control systems, electronic systems, even the Amtrak railroad system. The meanings of "system" are often confused. The most general, however, is: A system is a set of interacting units with relationships among them.[6] The word "set" implies that the units have some common properties, which is essential if they are to interact or have relationships. The state of each unit is constrained by, conditioned by, or dependent on the state of other units.[7] The units are coupled.

3.1 Conceptual system.

3.1.1 Units. Units of a conceptual system are terms, such as words (commonly nouns, pronouns, and their modifiers), numbers, or other symbols, including those in computer simulations and programs.

3.1.2 Relationships. A relationship of a conceptual system is a set of pairs of units, each pair being ordered in a similar way. E.g., the set of all pairs consisting of a number and its cube is the cubing relationship. Relationships are expressed by words (commonly verbs and their modifiers), or by logical or mathematical symbols, including those in computer simulations and programs, which represent operations, e.g., inclusion, exclusion, identity, implication, equivalence, addition, subtraction, multiplication,

or division. The language, symbols, or computer programs are all concepts and always exist in one or more concrete systems, living or nonliving, like a scientist, a textbook, or a computer.

3.2 Concrete system. A concrete system is a nonrandom accumulation of matter-energy, in a region in physical space-time, which is organized into interacting interrelated subsystems or components.

3.2.1 Units. The units (subsystems, components, parts, or members) of these systems are also concrete systems.[8]

3.2.2 Relationships. Relationships in concrete systems are of various sorts, including those that are structural, temporal, spatiotemporal, and meaningful.

Both units and relationships in concrete systems are empirically determinable by some operation carried out by an observer. In theoretical verbal statements about concrete systems, nouns, pronouns, and their modifiers typically refer to concrete systems, subsystems, or components; verbs and their modifiers usually refer to the relationships among them. There are numerous examples, however, in which this usage is reversed and nouns refer to patterns of relationships or processes, such as "nerve impulse," "reflex," "action," "vote," or "annexation."

3.2.3 Open system. Most concrete systems have boundaries which are at least partially permeable, permitting sizeable magnitudes of at least certain sorts of matter-energy or information transmissions to cross them. Such a system is an open system. The functions of such inputs include repairing system components that break down and replacing energy that is used up.

3.2.4 Closed system. A concrete system with impermeable boundaries through which no matter-energy or information transmission of any sort can occur is a closed system. No actual concrete system is completely closed, so concrete systems are either relatively open or relatively closed. Whatever matter-energy happens to be within a relatively closed system is essentially all there is going to be. The energy gradually is used up and the matter gradually becomes disorganized. A body in a hermetically sealed casket, for instance, slowly crumbles and its component molecules become intermingled. Separate layers of liquid or gas in a container move toward random distribution. Gravity may prevent entirely random arrangement.

3.2.5 Nonliving system. Every concrete system which does not have the characteristics of a living system is a nonliving system.

3.2.6 Living systems. The living systems are a special subset of the set of all possible concrete systems, composed of the plants and the animals. They all have the following characteristics:

(a) They are open systems.

(b) They use inputs of foods or fuels to restore their own energy and repair breakdowns in their own organized structure.

(c) They have more than a certain minimum degree of complexity.

(d) They contain genetic material composed of deoxyribonucleic acid (DNA), presumably descended from some primordial DNA common to all life, or have a charter, or both. One or both of these is the template--the original "blueprint" or "program"--of their structure and process from the moment of their origin.

(e) They are largely composed of protoplasm including proteins and other characteristic organic compounds.

(f) They have a decider, the essential critical subsystem which controls the entire system, causing its subsystems and components to interact.

(g) They also have certain other specific critical subsystems or they have symbiotic or parasitic relationships with other living or non-living systems which carry out the processes of any such subsystem they lack.

(h) Their subsystems are integrated together to form actively self-regulating, developing, reproducing unitary systems, with purposes and goals.

(i) They can exist only in a certain environment. Any change in their environment of such variables as temperature, air pressure, hydration, oxygen content of the atmosphere, or intensity of radiation, outside a relatively narrow range which occurs on the surfact of the earth, produces stresses to which they cannot adjust. Under such stresses they cannot survive.

3.3 Abstracted system.

3.3.1 Units. The units of abstracted systems are relationships abstracted or selected by an observer in the light of his interests, theoretical viewpoint, or philosophical bias. Some relationships may be empirically determinable by some operation carried out by the observer, but others are not, being only his concepts.

3.3.2 Relationships. The relationships mentioned above are observed to inhere and interact in concrete, usually living, systems. In a sense, then, these concrete systems are the relationships of abstracted systems. The verbal usages of theoretical statements concerning abstracted systems are often the reverse of those concerning concrete systems: the nouns and their modifiers typically refer to relationships and the verbs and their modifiers (including predicates) to the concrete systems in which these relationships inhere and interact. These concrete systems are empirically determinable by some operation carried out by the observer. A theoretical statement oriented to concrete systems typically would say "Lincoln was President," but one oriented to abstracted systems, concentrating on relationships or roles, would very likely be phrased "The Presidency was occupied by Lincoln."[9]

An abstracted system differs from an abstraction, which is a concept (like those that make up conceptual systems) representing a class of phenomena all of which are considered to have some similar "class characteristic." The members of such a class are not thought to interact or be interrelated, as are the relationships in an abstracted system.

Abstracted systems are much more common in social science theory than in natural science.

Parsons has attempted to develop general behavior theory using abstracted systems.[10] To some a social system is something concrete in space-time, observable and presumably measurable by techniques like those of natural science. To Parsons the system is abstracted from this, being

the set of relationships which are the form of organization. To him the important units are classes of input-output relationships of subsystems rather than the subsystems themselves.

3.4 Abstracted vs. concrete systems. One fundamental distinction between abstracted and concrete systems is that the boundaries of abstracted systems may at times be conceptually established at regions which cut through the units and relationships in the physical space occupied by concrete systems, but the boundaries of these latter systems are always set at regions which include within them all the units and internal relationships of each system.

A science of abstracted systems certainly is possible and under some conditions may be useful. When Euclid was developing geometry, with its practical applications to the arrangement of Egyptian real estate, it is possible that the solid lines in his figures were originally conceived to represent the borders of land areas or objects. Sometimes, as in Figure 1, he would use dotted "construction lines" to help conceptualize a geometric proof. The dotted line did not correspond to any actual border in space, Triangle ABD would be shown to be congruent to Triangle CBD, and therefore the angle BAD was equal to the angle BCD. After the proof was completed, the dotted line might well be erased, since it did not correspond to anything real and was useful only for the proof. Such construction lines, representing relationships among real lines, were used in the creation of early forms of abstracted systems.

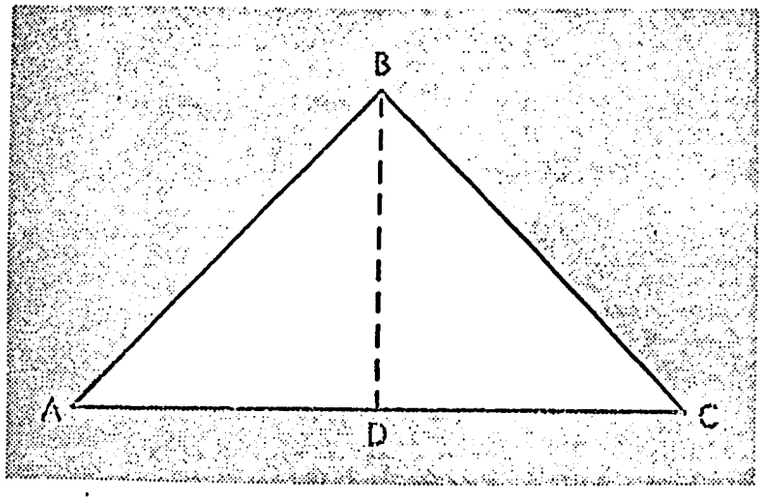

Figure 1. A Euclidean Figure

If the diverse fields of science are to be unified, it would help if all disciplines were oriented either to concrete or to abstracted systems. It is of paramount importance for scientists to distinguish clearly between them. To use both kinds of systems in theory leads to unneccesary problems. It would be best if one type of system or the other were generally used in all disciplines.

All three meanings of "system" are useful in science, but confusion results when they are not differentiated. A scientific endeavor may appropriately begin with a conceptual system and evaluate it by collecting data on a concrete or on an abstracted system or it may equally well first collect the data and then determine what conceptual system it fits. Throughout this monograph the single word "system," for brevity, will always mean "concrete system." The other sorts of systems will always be explicitly distinguished as either "conceptual system" or "abstracted system."

4. Structure

The structure of a system is the arrangement of its subsystems and components in three-dimensional space at a given moment of time. This always changes over time.[11] It may remain relatively fixed for a long period or it may change from moment to moment, depending upon the characteristics of the process in the system. This process halted at any given moment, as when motion is frozen by a high-speed photograph, reveals the three-dimensional spatial arrangement of the system's components as of that instant.

5. Process

All change over time of matter-energy or information in a system is process. If the equation describing a process is the same no matter whether the temporal variable is positive or negative, it is a reversible process; otherwise it is irreversible. Process includes the on-going function of a system, reversible actions succeeding each other from moment to moment. Process also includes history, less readily reversed changes like mutations, birth, growth, development, aging, and death; changes which commonly follow trauma or disease; and the changes resulting from learning which are not later forgotten. Historical processes alter both the structure and the function of the system. The statement "less readily reversed" has been used instead of "irreversible" (although many such changes are in fact irreversible) because structural changes sometimes can be reversed. E.g., a component which has developed and functioned may atrophy and finally disappear with disuse; a functioning part may be cut off and regrow. History, then, is more than the passage of time. It involves also accumulation in the system of residues or effects of past events (structural changes, memories, and learned habits). A living system carries its history with it in the form of altered structure, and consequently of altered function also. So there is a circular relation among the three primary aspects of systems--structure changes momentarily with functioning, but when such change is so great that it is essentially irreversible, a historical process has occurred, giving rise to a new structure.

6. Type

If a number of individual living systems are observed to have similar characteristics, they often are classed together as a type. Types are abstractions. Nature presents an apparently endless variety of living things which man, from his earliest days, has observed and classified--first, probably, on the basis of their threat to him, their susceptibility to capture, or their edibility, but eventually according to categories which are scientifically more useful. Classification by species is applied to organisms, plants or animals, or to free-living cells, because of their obvious relationships by reproduction. These systems are classified together by taxonomists on the basis of likeness of structure and process, genetic similarity and ability to interbreed, and local interaction, often including, in animals, ability to respond appropriately to each other's signs.

There are various types of systems at other levels of the hierarchy of living systems besides the cell and organism levels, each classed according to different structural and process taxonomic differentia. There are, for instance, the less developed primitive or agricultural societies, and there are industrial societies.

7. Level

The universe contains a hierarchy of systems, each higher level of system being composed of systems of lower levels.[12] Atoms are composed of particles; molecules, of atoms; crystals and organelles, of molecules.

About at the level of crystalizing viruses, like the tobacco mosaic virus, the subset of living systems begins. Viruses are necessarily parasitic on cells, so cells are the lowest level of living systems. Cells are composed of atoms, molecules, and multimolecular organelles; organs are composed of cells aggregated into tissues; organisms, of organs; groups (e.g., herds, flocks, families, teams, tribes), of organisms; organizations, of groups (and sometimes single individual organisms); societies, of organizations, groups, and individual organisms or persons; and supranational systems, of societies and organizations. Higher levels of systems may be of mixed composition, living and nonliving. They include planets, solar systems, galaxies, and so forth. It is beyond the scope of our concern in this report to deal with all the levels of systems. We shall be concerned only with five levels of living systems: organisms, groups, organizations, societies, and supranational systems.

What are the criteria for distinguishing any one level from the others? They are derived from a long scientific tradition of empirical observation of the entire gamut of living systems. This extensive experience of the community of scientific observers has led to a consensus that there are certain fundamental forms of organization of living matter-energy. Indeed the classical division of subject-matter among the various disciplines of the life or behavioral sciences is implicitly or explicitly based upon this consensus.

It is important to follow one procedural rule in systems theory, in order to avoid confusion. Every discussion should begin with an identification of the level of reference, and the discourse should not change to

another level without a specific statement that this is occurring.[13] System at the indicated level are called systems. Those at the level above are suprasystems, and at the next higher level, suprasuprasystems. Below the level of reference are subsystems, and below them subsubsystems. For example, if one is studying a group, its member organisms make up its subsystems, and an organization of which the group is a part is its supra-system.[14]

7.1 Intersystem generalization. A fundamental procedure in science is to make generalizations from one system to another on the basis of some similarity between the systems, which the observer sees and which permits him to class them together. For example, since the Nineteenth Century, the field of "individual differences" has been expanded, following the tradition of scientists like Galton in anthropometry and Binet in psychometrics. In Figure 2, states of separate specific individual systems on a specific structural or process variable are represented by I_1 to I_n. For differences among such individuals to be observed and measured, of course, a variable common to the type, along which there are individual

$$\underbrace{\underbrace{I_1 \ldots I_n}_{T_1 \ldots T_n}}_{L_1 \ldots L_n}$$

Figure 2. Individual, Type, Level.

variations, must be recognized (T_1). Physiology depends heavily, for instance, upon the fact that individuals of the type (or species) of living organisms called cats are fundamentally alike, even though minor variations from one individual to the next are well recognized.

Scientists may also generalize from one type to another (T_1 to T_n). An example is cross-species generalization, which has been commonly accepted only since Darwin. It is the justification for the labors of the white rat in the cause of man's understanding of himself. Rats and cats, cats and chimpanzees, chimpanzees and human beings are similar in structure, as comparative anatomists know, and in function, as comparative physiologists and psychologists demonstrate.

The amount of variance among species is greater than among individuals within a species. If the learning behavior of cat Felix is compared with that of mouse Mickey, we would expect not only the sort of individual differences which are found between Mickey and Minnie Mouse, but also greater species differences. Cross-species generalizations are common, and many have good scientific acceptability, but in making them, inter-individual and interspecies differences must be kept in mind. The learning rate of men is not identical to that of white rats, and no single man learns at exactly the same rate as any other.

The third type of scientific generalization indicated in Figure 2 is from one level to another. The basis for such generalization is the assumption that each of the levels of life, from cell to society, is composed of systems of the previous lower level. These cross-level generalizations will, ordinarily, have greater variance than the other

sorts of generalizations, since they include variance among types and among individuals. But they can be made, and they can have great conceptual significance.

That there are important uniformities, which can be generalized about, across all levels of living systems is not surprising. All are composed of comparable carbon-hydrogen-nitrogen constituents, most importantly a score of amino acids organized into similar proteins, which are produced in nature only in living systems. All are equipped to live in a water-oxygen world rather than, for example, on the methane and ammonia planets so dear to science fiction. Also they are all adapted only to environments in which the physical variables, like temperature, hydration, pressure, and radiation, remain within relatively narrow ranges.[15] Moreover, they all presumably have arisen from the same primordial genes or template, diversified by evolutionary change. Perhaps the most convincing argument for the plausibility of cross-level generalization derives from analysis of this evolutionary development of living systems. Although increasingly complex types of living systems have evolved at a given level, followed by higher levels with even greater complexity, certain basic necessities did not change. All these systems, if they were to survive in their environment, had, by some means or other, to carry out the same vital subsystem processes. While free-living cells, like protozoans, carry these out with relative simplicity, the corresponding processes are more complex in multicellular organisms like mammals, and even more complex in organizations, societies, and supranational systems. The same processes are "<u>shredded out</u>" to multiple components in a more complex system, by the sort of <u>division of</u>

labor which Parkinson has made famous as a law.[16] This results in formal identities across levels of systems, more complex subsystems at higher levels carrying out the same fundamental processes as simpler subsystems at lower levels.

A formal identity among concrete systems is demonstrated by a procedure composed of three logically independent steps: (a) recognizing an aspect of two or more systems which has comparable status in those systems; (b) hypothesizing a quantitative identity between them; and (c) demonstrating that identity within a certain range of error by collecting data on a similar aspect of each of the two or more systems being compared. It may be possible to formulate some useful generalizations which apply to all living systems at all levels. A comparision of systems is complete only when statements of their formal identities are associated with specific statements of their interlevel, intertype, and interindividual disidentities. The confirmation of formal identities and disidentities is done by research.

What makes interindividual, intertype, or interlevel formal identities among systems important and of absorbing interest, is that--if they can be conclusively demonstrated--very different structures, which carry out similar processes, may well turn out to carry out acts so much alike that they can be quite precisely described by the same formal model. Conversely, it may perhaps be shown as a general principle that subsystems with comparable structures but quite different processes may have quantitative similarities as well.

7.2 Emergents. The more complex systems at higher levels manifest characteristics, more than the sum of the characteristics of the units, not observed at lower levels. These characteristics have been called emergents. Significant aspects of living systems at higher levels will be neglected if they are described only in terms and dimensions used for their lower-level subsystems and components.

A clear-cut illustration of emergents can be found in a comparison of three electronic systems. One of these--wire connecting the poles of a battery--can only conduct electricity, which heats the wire. Add several tubes, condensers, resistors, and controls, and the new system can become a radio, capable of receiving sound messages. Add dozens of other components, including a picture tube and several more controls, and the system becomes a television set which can receive sound and a picture. And this is not just more of the same. The third system has emergent capabilities the first system did not have, emergent from its special design of much greater complexity, just as the second has capabilities the first lacked. But there is nothing mystical about the colored merry-go-round and racing children on the TV screen--it is the output of a system which can be completely explained by a complicated set of differential equations such as electrical engineers write, including terms representing the characteristics of each of the set's components.

8. Echelon

This concept may seem superficially similar to the concept of level, but is distinctly different. Many complex living systems, at various levels, are organized into two or more echelons (in the military sense of a step in

the "chain of command," not in the other military sense of arrangement of troops in rows in physical space). In living systems with echelons the components of the decider, the decision-making subsystem, are hierarchically arranged so that usually certain types of decisions are made by one component of that subsystem and others by another. Each is an echelon. All echelons are within the boundary of the decider subsystem. Ordinarily each echelon is made up of components of the same level as those which make up every other echelon in that system. Characteristically the decider component at one echelon gets information from a source or sources which process information primarily or exclusively to and from that echelon.

After a decision is made at one echelon on the basis of the information received, it is transmitted, often through a single subcomponent which may or may not be the same as the decider, but possibly through more than one subcomponent, upward to the next higher echelon, which goes through a similar process, and so on to the top echelon. Here a final decision is made and then command information is transmitted downward to lower echelons. Characteristically information is abstracted or made more general as it proceeds upward from echelon to echelon and it is made more specific or detailed as it proceeds downward. If a given component does not decide but only passes on information, it is not functioning as an echelon. In some cases of decentralized decision making, certain types of decisions are made at lower echelons and not transmitted to higher echelons in any form, while information relevant to other types of decisions is transmitted upward. If there are multiple parallel deciders, without a hierarchy that has subordinate and superordinate deciders, there is not one system but multiple ones.

9. Suprasystem

9.1 Suprasystem and environment. The suprasystem of any living system is the next higher system in which it is a component or subsystem. For example, the suprasystem of a cell or tissue is the organ it is in; the suprasystem of an organism is the group it is in at the time. Presumably every system has a suprasystem except the "universe." The suprasystem is differentiated from the environment. The immediate environment is the suprasystem minus the system itself. The entire environment includes this plus the suprasuprasystem and the systems at all higher levels which contain it. In order to survive the system must interact with and adjust to its environment, the other parts of the suprasystem. These processes alter both the system and its environment. Living systems adapt to their environment, and in return mold it. The result is that, after some period of interaction, each in some sense becomes a mirror of the other.

9.2 Territory. The region of physical space occupied by a living system, and frequently protected by it from an invader, is its territory.[17] Examples are a bowerbird's stage, a dog's yard, a family's property, a nation's land.

10. Subsystem and Component

In every system it is possible to identify one sort of unit, each of which carries out a distinct and separate process, and another sort of unit, each of which is a discrete, separate structure. The totality of all the structures in a system which carry out a particular process is a

subsystem. A subsystem, thus, is identified by the process it carries out. It exists in one or more identifiable structural units of the system. These specific, local, distinguishable structural units are called components or members or parts. Reference has been made to these components in the definition of a concrete system as "a nonrandom accumulation of matter-energy, in a region in physical space-time, which is organized into interacting, interrelated subsystems or components." There is no one-to-one relationship between process and structure. One or more processes may be carried out by two or more components. Every system is a component, but not necessarily a subsystem of its suprasystem. Every component that has its own decider is a system at the next lower level, but many subsystems are not systems at the next lower level, being dispersed to several components.

The concept of subsystem process is related to the concept of role used in social science.[18] Organization theory usually emphasizes the functional requirements of the system which the subsystem fulfills, rather than the specific characteristics of the component or components that make up the subsystem. The typical view is that an organization specifies clearly defined roles (or component processes) and human beings "fill them."[19] But it is a mistake not to recognize that characteristics of the component--in this case the person carrying out the role--also influence what occurs. A role is more than simple "social position." It involves interaction, adjustments between the component and the system. It is a multiple concept, referring to the demands upon the component by the system, to the internal adjustment processes of the component, and to

how the component functions in meeting the system's requirements. The adjustments it makes are frequently compromises between the requirements of the component and the requirements of the system.

The way living systems develop does not always result in a neat distribution of exactly one subsystem to each component. The natural arrangement would appear to be for a system to depend on one structure for one process. But there is not always such a one-to-one relationship. Sometimes the boundaries of a subsystem and a component exactly overlap, are congruent. Sometimes they are not congruent. There can be (a) a single subsystem in a single component; (b) multiple subsystems in a single component; (c) a single subsystem in multiple components; or (d) multiple subsystems in multiple components.

Systems differ markedly from level to level, type to type, and even from individual to individual, in their patterns of allocation of various subsystem processes to different structures. Such process may be (a) localized in a single component; (b) combined with others in a single component; (c) dispersed laterally to other components in the system; (d) dispersed upwardly to the suprasystem or above; (e) dispersed downwardly to subsubsystems or below; or (f) dispersed outwardly to other systems external to the hierarchy it is in. Which allocation pattern is employed is a fundamental aspect of any given system. For a specific subsystem function in a specific system one strategy results in more efficient process than another. One can be better than another in maximizing effectiveness and minimizing costs. Valuable studies can be made at each level on optimal patterns of allocation of processes to structures. In all probability

there are general systems principles which are relevant to such matters. Possible examples are: (a) Structures which minimize the distance over which matter-energy must be transported or information transmitted are the most efficient. (b) If multiple components carry out a process, the process is more difficult to control and less efficient than if a single component does it. (c) If one or more components which carry out a process are outside the system, the process is more difficult to integrate than if they are all in the system. (d) Or if there are duplicate components capable of performing the same process, the system is less vulnerable to stress and therefore is more likely to survive longer, because if one component is inactivated, the other can carry out the process alone.

10.1 Critical subsystem. Certain processes are necessary for life and must be carried out by all living systems that survive or be performed for them by some other system. They are carried out by the following critical subsystems listed in Table 1.

The definitions of the critical subsystems are as follows:

10.1.1 Subsystems which process both matter-energy and information.

Reproducer, the subsystem which is capable of giving rise to other systems similar to the one it is in.

Boundary, the subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.

10.1.2 Matter-energy processing subsystems.

Ingestor, the subsystem which brings matter-energy across the system boundary from the environment.

Matter-Energy Processing Subsystems	Subsystems Which Process Both Matter-Energy and Information	Information Processing Subsystems
	Reproducer	
	Boundary	
Ingestor		Input Transducer
		Internal Transducer
Distributor		Channel and Net
Converter		Decoder
Producer		Associator
Matter-Energy Storage		Memory
		Decider
		Encoder
Extruder } Motor }		Output Transducer
Supporter		

Table 1. The Critical Subsystems.

Distributor, the subsystem which carries inputs from outside the system or outputs from its subsystems around the system to each component.

Converter, the subsystem which changes certain inputs to the system into forms more useful for the special processes of that particular system.

Producer, the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products or information markers to its suprasystem.

Matter-energy storage, the subsystem which retains in the system, for different periods of time, deposits of various sorts of matter-energy.

Extruder, the subsystem which transmits matter-energy out of the system in the forms of products and wastes.

Motor, the subsystem which moves the system or parts of it in relation to part or all of its environment or moves components of its environment in relation to each other.

Supporter, the subsystem which maintains the proper spatial relationships among components of the system, so that they can interact without weighting each other down or crowding each other.

10.1.3 Information processing subsystems.

Input transducer, the sensory subsystem which brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it.

Internal transducer, the sensory subsystem which receives, from all subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it.

Channel and net, the subsystem composed of a single route in physical space, or multiple interconnected routes, by which markers bearing information are transmitted to all parts of the system.

Decoder, the subsystem which alters the code of information input to it through the input transducer or the internal transducer into a "private" code that can be used internally by the system.

Associator, the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system. (The main topic of this report is the associator subsystem or educational sector of a particular less developed nation or society.)

Memory, the subsystem which carries out the second stage of the learning process, storing various sorts of information in the system for different periods of time.

Decider, the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs that control the entire system.

Encoder, the subsystem which alters the code of information inputs to it from other information processing subsystems, from a "private" code used internally by the system into a "public" code which can be interpreted by other systems in its environment.

Output transducer, the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment.

Of these critical subsystems only the decider is essential, in the sense that a system cannot be dependent on another system for its deciding. There is no living system if the decider is dispersed upwardly, downwardly, or outwardly.

Since all living systems are genetically related, have similar constituents, live in closely comparable environments, and process matter-energy and information, it is not surprising that they should have comparable subsystems and relationships among them. All systems do not have all possible kinds of subsystems. They differ individually, among types, and across levels, as to which subsystems they have and the structures of those subsystems. But all living systems either have a complete complement of the above listed critical subsystems carrying out the functions essential to life or are intimately associated with and effectively interacting with systems which carry out the missing life functions for them.

10.2 Inclusion. Sometimes a part of the environment is surrounded by a system and totally included within its boundary. Any such thing not a part of the system's own living structure is an inclusion. Any living system at any level may include living or nonliving components. To the two-member group of one dog and one cat, for instance, an important plant

component is often added--one tree. An airline firm may have as an integral component a computerized mechanical system for making reservations which extends into all its offices. A nation includes many sorts of vegetables, minerals, buildings, and machines, as well as its land.

The inclusion is a component or subsystem of the system if it carries out or helps in carrying out a critical process of the system; otherwise it is part of the environment. Either way the system, to survive, must adjust to its characteristics. If it is harmless or inert it can often be left undisturbed. But if it is potentially harmful--like a pathogenic bacterium in a dog or a Greek in the giant gift horse within the gates of Troy--it must be rendered harmless or walled off or extruded from the system or killed. Because it moves with the system in a way the rest of the environment does not, it constitutes a special problem. Being inside the system it may be a more serious or more immediate stress than it would be outside the system's protective boundary. But also, the system that surrounds it can control its physical actions and all routes of access to it. For this reason international law has developed the concept of extraterritoriality to provide freedom of action to ambassadors and embassies, nations' inclusions within foreign countries.

10.3 Artifact. An artifact is an inclusion in some system, made by animals or man. Spider webs, bird nests, beaver dams, houses, books, machines, music, paintings, and language are artifacts. They may or may not be prostheses, inventions which carry out some critical process essential

to a living system. An artificial pacemaker for a human heart is an example of an artifact which can replace a pathological process with a healthy one. Instructional technologies are artifacts which function as prostheses in educational systems at the level of the individual student or organism and at higher levels. Chemical, mechanical, or electronic artifacts have been constructed which carry out some functions at all levels of living systems.

Living systems create and live among their artifacts. Beginning presumably with the hut and the arrowhead, the pot and the vase, the plow and the wheel, mankind has constructed tools and devised machines. The Industrial Revolution of the Nineteenth Century, capped by the recent harnessing of atomic energy, represents the extension of man's matter-energy processing ability, his muscles. A new Industrial Revolution, of even greater potential, is just beginning in the Twentieth Century, with the development of information and logic-processing machines, adjuncts to man's brain. These artifacts are increasingly becoming prostheses, relied on to carry out critical subsystem processes. A chimpanzee may extend his reach with a stick; a man may extend his cognitive skills with a computer. Today's prostheses include input transducers which sense the type of blood cells that pass before them and identify missiles that approach a nation's shores; photographic, mechanical, and electronic memories which can store masses of information over time; computers which can solve problems, carry out logical and mathematical calculations, make decisions, and control other machines; electric typewriters, high speed

printers, cathode ray tubes, and photographic equipment which can output information. An analysis of many modern systems must take into account the novel problems which arise at man-machine interfaces.

Music is a special sort of human artifact, an information-processing artifact.[20] So are the other arts and cognitive systems which people share. So is language. Whether it be a natural language or the machine language of some computer system, it is essential to information processing. Often stored only in human brains and expressed only by human lips, it can also be recorded on nonliving artifacts like stones, books, and magnetic tapes. It is not of itself a concrete system. It changes only when man changes it. As long as it is used it is in flux, because it must remain compatible with the ever-changing living systems that use it. But the change emanates from the users, and without their impact the language is inert. The artifactual language used in any information transmission in a system determines many essential aspects of that system's structure and process.[21]

11. Transmissions in Concrete Systems

All process involves some sort of transmission among subsystems within a system, or among systems. There are inputs across the boundary into a system, internal processes within it, and outputs from it. Each of these sorts of transmissions may consist of either (a) some particular form of matter; (b) energy, in the form of light, radiant energy, heat, or chemical energy; or (c) some particular pattern of information.

12. Steady State

When opposing variables in a system are in balance, that system is in equilibrium with regard to them. The equilibrium may be static and unchanging or it may be maintained in the midst of dynamic change. Since living systems are open systems, with continually altering fluxes of matter-energy and information, many of their equilibria are dynamic and are often referred to as flux equilibria of steady states. These may be unstable, in which a slight disturbance elicits progressive change from the equilibrium state--like a ball standing on an inverted bowl; or stable, in which a slight disturbance is counteracted so as to restore the previous state--like a ball in a cup; or neutral, in which a slight disturbance makes a change, but without cumulative effects of any sort--like a ball on a flat surface with friction.

All living systems tend to maintain steady states (or homeostasis) of many variables, keeping an orderly balance among subsystems which process matter-energy or information. Not only are subsystems usually kept in equilibrium, but systems also ordinarily maintain steady states with their environments and suprasystems, which have outputs to the systems and inputs from them. This prevents variations in the environment from destroying systems. The variables of living systems are constantly fluctuating, however. A moderate change in one variable may produce greater or lesser alterations in other related ones. These alterations may or may not be reversible.

12.1 Stress, strain, and threat. There is a range of stability for each of numerous variables in all living systems. It is that range within which the rate of correction of deviations is minimal or zero, and beyond which correction occurs. An input or output of either matter-energy or information, which by lack or excess of some characteristic, forces the variables beyond the range of stability, constitutes a stress and produces a strain (or strains) within the system. Input lack and output excess both produce the same strain--diminished amounts in the system. Input excess and output lack both produce the opposite strain--increased amounts. Strains may or may not be capable of being reduced, depending upon their intensity and the resources of the system. The totality of the strains within a system resulting from its template program and from variations in the inputs from its environment can be referred to as its values. The relative urgency of reducing each of these specific strains represents its hierarchy of values.

Stress may be anticipated. Information that a stress is imminent constitutes a threat to the system. A threat can create a strain. Recognition of the meaning of the information of such a threat must be based on previously stored (usually learned) information about such situations. A pattern of input information is a threat when--like the odor of the hunter on the wind or a whirling cloud approaching the city--it is capable of eliciting processes which can counteract the stress it presages. Processes--actions or communications--occur in systems only when a stress or a threat has created a strain which pushes a variable beyond its range of stability. A system is a constantly changing cameo and its environment is a similarly

changing intaglio, and the two at all times fit each other. That is, outside stresses or threats are mirrored by inside strains. Matter-energy storage and memory also mirror the past environment, but with certain alterations.

12.1.1 Matter-energy stress. There are various ways for systems to be stressed. One class of stresses is the matter-energy stresses, including: (a) matter-energy input lack or underload--starvation or inadequate fuel input; (b) input of an excess or overload of matter-energy; and (c) restraint of the system, binding it physically. [This may be the equivalent of (a) or (b).]

12.1.2 Information stress. Also there are information stresses, including: (a) information input lack or underload, resulting from a dearth of information in the environment or from improper function of the external sense organs or input transducers; (b) injection of noise into the system, which has an effect of information cut-off, much like the previous stress; and (c) information input excess or overload. Informational stresses may involve changes in the rate of information input or in its meaning.

12.2 Adjustment processes. Those processes of subsystems which maintain steady states in systems, keeping variables within their ranges of stability despite stresses, are adjustment processes. In some systems a single variable may be influenced by multiple adjustment processes. As Ashby has pointed out, a living system's adjustment processes are so coupled that the system is ultrastable.[22] This characteristic can be illustrated by the example of an army cot. It is made of wires, each of

which would break under a 300-pound weight, yet it can easily support a sleeper of that weight. The weight is applied to certain wires, and as it becomes greater, first nearby links and then those farther and farther away, take up part of the load. Thus a heavy weight which would break any of the component wires alone can be sustained. In a living system, if one component cannot handle a stress, more and more others are recruited to help. Eventually the entire capacity of the system may be involved in coping with the situation.

12.2.1 Feedback. The term feedback means that there exist two channels, carrying information, such that Channel B loops back from the output to the input of Channel A and transmits some portion of the signals emitted by Channel A (see Figure 3).[23] These are tell-tales or monitors of the outputs of Channel A. The transmitter on Channel A is a device with two inputs, formally represented by a function with two independent variables, one the signal to be transmitted on Channel A and the other a previously transmitted signal fed back on Channel B. The new signal transmitted on Channel A is selected to decrease the strain resulting from any

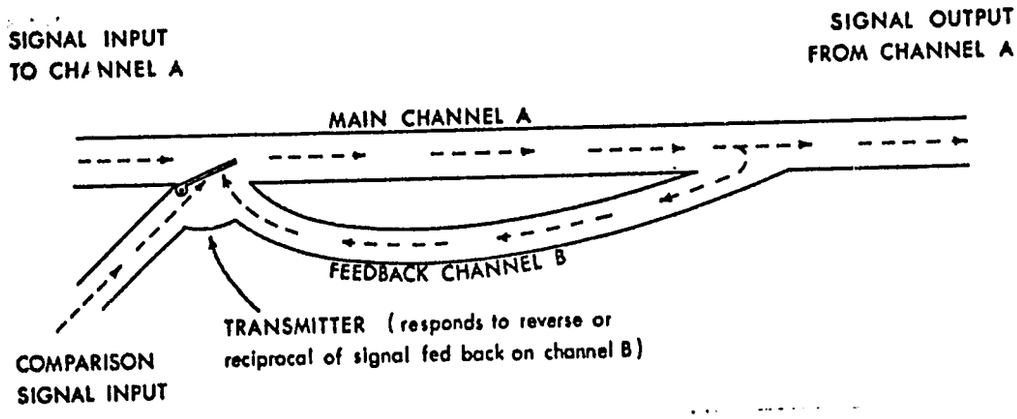

Figure 3. Negative Feedback

error or deviation in the feedback signal from a criterion or comparison reference signal indicating the state of the output of Channel A which the system seeks to maintain steady. This provides control of the output of Channel A on the basis of actual rather than expected performance.

When the signals are fed back over the feedback channel in such a manner that they increase the deviation of the output from a steady state, positive feedback exists. When the signals are reversed, so that they decrease the deviation of the output from a steady state, it is negative feedback. Positive feedback alters variables and destroys their steady states. Thus it can initate system changes. Unless limited, it can alter variables enough to destroy systems. At every level of living systems numerous variables are kept in a steady state, within a range of stability, by negative feedback controls. When these fail, the structure and process of the system alter markedly--perhaps to the extent that the system does not survive. Feedback control always exhibits some oscillation and always has some lag. When the organism maintains its balance in space, this lag is caused by the slowness of transmissions in the nervous system, but is only of the order of hundredths of seconds. An organization, like a corporation, may take hours to correct a breakdown in an assembly line, days or weeks to correct a bad management decision. In a society the lag can sometimes be so great that, in effect, it comes too late. General staffs often plan for the last war rather than the next. Governments receive rather slow official feedbacks from the society at periodic elections. They can, however, get faster feedbacks from the press, other mass media, picketers, or demonstrators. Public opinion surveys can

accelerate the social feedback process. The speed and accuracy of feedback have much to do with the effectiveness of the adjustment processes they mobilize.

12.2.2 Power. In relation to energy processing, power is the rate at which work is performed, work being calculated as the product of a force and the distance through which it acts. The term also has another quite different meaning. In relation to information processing, power is control, the ability of one system to elicit compliance from another, at the same or a different level. A system transmits a command signal or message to a given address with a signature identifying the transmitter as a legitimate source of command information. The message is often in the imperative mode, specifying an action the receiver is expected to carry out. It elicits compliance at the lower levels because the electrical or chemical form of the signal sets off a specific reaction. At higher levels the receiving system is likely to comply because it has learned that the transmitter is capable of evoking rewards or punishments from the suprasystem, depending on how the receiver responds.

12.2.3 Purpose and goal. By the information input of its charter or genetic input, or by changes in behavior brought about by rewards and punishments from its suprasystem, a system develops a preferential hierarchy of values that gives rise to decision rules which determine its preference for one internal steady state value rather than another. This is its purpose. It is the comparison value which it matches to information received by negative feedback in order to determine whether the variable is being maintained at the appropriate steady state value. In this sense it is normative. The system then takes one alternative action rather than another because it appears most likely to maintain the steady state. When disturbed, this

state is restored by the system by successive approximations, in order to relieve the strain of the disparity recognized internally between the feedback signal and the comparison signal. Any system may have multiple purposes simultaneously.

A system may also have an external goal, such as reaching a target in space, or developing a relationship with any other system in the environment. Or it may have several goals at the same time. Just as there is no question that a guided missile is zeroing in on a target, so there is no question that a rat in a maze is searching for the goal of food at its end or that the Greek people under Alexander the Great were seeking the goal of world conquest. As Ashby notes, natural selection permits only those systems to continue which have goals that enable them to survive in their particular environments.[24] The external goal may change constantly, as when a hunter chases a moving fox or a man searches for a wife by dating one girl after another, while the internal purpose remains the same.

A system's hierarchy of values determines its purposes as well as its goals. It is not difficult to distinguish purposes from goals, as the terms have been used: a boy has the purpose of keeping his body temperature in the proper range and so he has the goal of finding and putting on his sweater; Poland had the purpose in March 1939 of remaining uninvaded and autonomous and so she sought the goal of a political alliance with Britain and France in order to have assistance in keeping both Germany and Russia from crossing her borders.

12.2.4 Costs and efficiency. All adjustment processes have their costs, in energy of nonliving or living systems, in material resources, in information (including in social systems a special form of information, money, often conveyed on a metal or paper marker), or in time required for an action. Any of these may be scarce. (Time is a scarcity for mortal

living systems.) Any of these is valued if it is essential for reducing strains. The costs of adjustment processes differ from one to another and from time to time. They may be immediate or delayed, short-term or long-term.

How successfully systems acomplish their purposes can be determined if those purposes are known. A system's efficiency, then, can be determined as the ratio of the success of its performance to the costs involved. A system constantly makes economic decisions directed toward increasing its efficiency by decreasing costs and improving performance or effectiveness. Economic analyses of cost-effectiveness are in recent years frequently aided by program budgeting. This involves keeping accounts separately for each subsystem or component that carries out a distinct program. The matter-energy, information, money, and time costs of the program are in such analyses compared with various measures of the effectiveness or performance of the program. How efficiently a system adjusts to its environment is determined by what strategies it employs in selecting adjustment processes and whether they satisfactorily reduce strains without being too costly. This decision process can be analyzed by game theory, a mathematical approach to economic decisions. This is a general theory concerning the best strategies for weighing "plays" against "pay-offs," for selecting actions which will increase profits while decreasing losses, increase rewards while decreasing punishments, improve adjustments of variables to appropriate steady state values, or attain goals while diminishing costs. Relevant information available to the decider can improve such decisions. Consequently such information is valuable. But there are costs to obtaining such information.

13. Conclusion

This analysis of living systems uses concepts of thermodynamics, information theory, cybernetics, and systems engineering, as well as the classical concepts appropriate to each level. The purpose is to produce a description of living structure and process in terms of input and output, flows through systems, steady states, and feedbacks, which will clarify and unify the facts of life. In the subsequent chapters these systems concepts will be applied to a particular class of living systems--educational systems. Emphasis will be placed on the potential of a particular class of artifacts--the new information processing technologies--for improving the quality and efficiency of educational programs and cutting their costs.

CHAPTER I

Notes and References

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12. Note: This concept is not a product of our times. It was developed long ago. For instance, in the middle of the Nineteenth Century, Virchow (Virchow, R. Atome und Individuen, Vier Reden Uber Leben und Krankstein. Berlin, 1862. Trans. by L. J. Rather as: Atoms and individuals. In Disease, life, and man, selected essays by Rudolph Virchow. Stanford, Calif.: Stanford Univ. Press, 1958, 120-141.) wrote that the scope of the life sciences must include the cellular, tissue, organism, and social levels of living organization In modern times the concept of hierarchical levels of systems is basic t to the thought of Bertalanffy and other general systems theorists. (Bertalanffy, L. v. Op. cit., 7.)

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CHAPTER II

THE LIVING SYSTEMS INVOLVED IN THE EDUCATIONAL PROCESS

1. The Levels of Educational Systems

How can the concepts of general systems theory be applied to increase our understanding of the educational process in less developed nations and our ability to improve it? A number of levels of living systems are involved in this process, carried out by the associator subsystem, i.e., the educational sector (see pages 37 and 39) of the particular society in a given country.

At the organism level, there are several sorts of persons: the student, the parent, the teacher, the paraprofessional teacher, the administrator, and other employees of educational institutions. At the group level: the class in the classroom, the teacher and student in a tutorial session, or the studio team in an educational television station. At the organization level: in primary and secondary education, the school, and in higher education, the college or university; also at a higher echelon, the school system or the statewide educational agency which coordinates formal education and at times a part of the more inclusive nonformal education. At the society level: the national educational system, which exercises little centralized control in the United States but is much more centralized in the Soviet Union, Brazil, and elsewhere. Finally, at the supranational level: UNESCO, the Economic and Social Council of the United Nations, INNOTECH of the

eight Southeast Asian nations, the Pan American Federation of Associations of Schools of Medicine, and other such activities are producing the first glimmerings of international coordination of education.

We shall now discuss in turn each of these levels of living systems involved in education of less developed countries, applying the concepts outlined in Chapter I.

2. Level of the Organism: The Persons in the Educational Process

The central person in all of education is the student. During the time he is studying, at school or elsewhere, the needs of his matter-energy processing subsystems must be provided for--food for his ingestor; clothes and heat on his boundary to warm all his subsystems; lavatories for his extruder; walks, hallways, and exercise facilities for his motor. There must be facilities for his information processing subsystems as well--classrooms for discussions, recitations, and lectures, and to the extent they can be afforded, artifacts such as books, television, computerized programmed instruction, and audiovisual aids for his input transducer, which sends information over his channel and net subsystem to his associator; language teachers and language laboratories for his decoder and encoder; academic advisers and counselors on personal problems to transmit information over his input transducer and channel and net to his decider; classrooms, auditoriums, and speech laboratories for his output transducer.

Students are of different types--males and females, children and adults, all races, and many genetic strains. Their different physical, mental, emotional, and motivational characteristics mean that they have various needs which often are best met by individualized attention. Being human, students have highly complex nervous systems, decisions being made at several neural echelons, from the local adjustment processes of the spinal cord up to the subtlest creative processes of the cortex of the brain. As he matures each student must learn from his parents and teachers how to govern or control (a) his subsystems and components, his viscera and other organs (Freud used the term "id" to refer to such governance and the emotions and motivations related to it); (b) his entire system (Freud's "ego"); and (c) his system in relation to other persons in his suprasystem (Freud's "superego.") He must also learn how to use the common as well as the new and sophisticated artifacts which are becoming more and more important in our modern technological society. No education deals with the whole student unless it relates to his mental, emotional, motivational, physical, social, cultural, and technological adjustments.

Education is primarily an information processing activity of the student, involving many, and often repeated, information inputs to him and outputs from him as well as much internal processing in his nervous system. Thus he learns to use language, think, solve problems, make decisions, and adjust to the threats and stresses of life. Education involves learning many facts but it is more important for the student to discover where to find facts and how to make the adjustments required

by a wide range of threats and stresses. One of the things that every educated person must learn, in one set of terms or another, is that adjustments are more adaptive if they are continually subjected to checks in order to discover whether they are optimally achieving their goals. This is accomplished by using negative feedbacks. A soprano checks her tones by playing back a tape recording she has just made. A student checks his progress by the monthly grades on his report card and, if he is motivated, works harder in those classes where he got the lowest grades. An athlete considers his previous year's batting average in deciding whether to try to make the baseball team again this year.

Even in early childhood students begin to learn about power--how to influence others to do what they want of them. This is a fundamental part of life. A person usually exercises power to accomplish his own goals which are established in terms of his long-run purposes. All of this relates to the most intimate aspects of his personality, his motivations, and his hierarchy of values. These are commonly learned more from informal and extracurricular personal interactions with parents, teachers, and fellow students than in the classroom. There is no indication that television or the computer or any other innovation of educational technology can in the foreseeable future substitute for this personal touch. Any educational system whose size or organizational arrangements makes such human contacts infrequent cannot accomplish one of its central missions. Anonymity is not the optimal climate for learning.

The individual student profits if, sometime in his education, he becomes proficient in taking an economic approach to the planning of his life. He must learn to husband scarce resources--friends who can help him,

his own time and money, and useful materials and services. He must learn that for every benefit there is a cost and that it is to his advantage to optimize the trade-offs of costs and benefits. This makes for efficiency of personal decision making. Of course few human decisions are made by quantitative calculations. Often their bases cannot even be stated. But in actuality many personal decisions, especially major ones, involve cost-effectiveness evaluations. Education can develop a student's skills in making such evaluations.

Thus a student may be viewed as a living system, as can his family, his teachers and friends, and the other persons concerned in his education. Ordinarily, major purposes and goals of all these are altruistically centered on helping the student in his learning process. But they are all human beings intent also on achieving their personal purposes. Otherwise there would not be teachers' unions; otherwise some parents would be more willing than they are to help their children with their homework. Anyone who wishes to understand education or any other social process must recognize that every human being tends to optimize the achievement of his own purposes and goals and these cannot all be altruistic. Fortunately for students, many of them are.

3. Higher Levels of Educational Systems

Table 2 identifies the critical subsystems of educational systems (see Table 1, page 37) at the levels of the group (a class), organization (a school), society (a national formal and nonformal educational system), and supranational system (an international system for sharing resources among countries for formal and nonformal education).

Table 2

Level / Critical Subsystem	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Reproducer	Parents of students, teacher, or paraprofessional; teacher, paraprofessional, or students who set up class organization and procedures; artifacts such as writing materials for writing these down	City planning committee for new schools; artifacts such as writing materials for writing plans, procedures, regulations	Writers of charter of national educational system; persons or groups who initiate nonformal educational systems; artifacts such as writing or printing materials for recording charter	Persons, groups, or organizations from two or more countries who devise charter for the international educational system; artifacts such as writing or printing materials for recording charter
Boundary	Teacher that keeps out of class persons who do not belong, admitting only class members; teacher who decides what the class shall and shall not read; artifacts like classroom walls, doors	Guards, janitors, police; artifacts like walls, gates, fences	Security guards, national police, educators who travel abroad; artifacts like walls, gates, fences	Security or international system; persons, groups, or organizations who bring information to it from nonmember countries; artifacts like walls, gates, fences
Ingestor	Person who brings food or drink for class students; person who brings other supplies, furniture, or appartus; person who provides heat or light; person who recruits students, teachers, or paraprofessionals; artifacts like area of classroom around door	Persons at information desk; principal or teachers; admissions office; personnel office; electrical and heating engineers; receiving room personnel; artifacts like lobby of school, information desk, receiving room	Persons, groups, or organizations that receive supplies, furniture, equipment, or heat, light, or electricity for national educational system; persons that recruit personnel and students; artifacts they use, like vehicles	Persons, groups, organizations, or societies that receive matter-energy or recruit personnel to staff the system or receive students; artifacts they use, like transportation facilities
Distributor	Teacher, paraprofessional, or student who passes out supplies, food, or drink to others in the class, arranges furniture, or seats new students; artifacts like aisles in classrooms	Buildings and grounds and maintenance departments; electrical and heating engineers; busboys; food handlers; artifacts like school hallways, passageways, stairs, elevators, conveyor belts, electrical wires and fuse boxes, steam pipes	Persons, groups, or organizations that distribute educational supplies and equipment, including instructional aids, as well as educators and students throughout national system; artifacts like trucks, railroads, airplanes, and other means of transportation used for such purposes	Persons, groups, or organizations that distribute educational supplies and equipment, including instructional aids, as well as educators and students throughout the international system; artifacts like airplanes, ships, and other transportation facilities used for such purposes

(cont.)

Critical Subsystem \ Level	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Converter	Teacher or other person who makes sandwiches for students, prepares reagents for a chemistry demonstration, cuts wood or metal for equipment, or cuts firewood; artifacts such as tools used to do these things	Cooks, electrical and heating engineers; artifacts like stoves, cooking utensils, tools, heaters	Persons, groups, or organizations that generate electricity, refine oil, or prepare raw materials for educational equipment and buildings to be used in the system; tools, machines, and other artifacts used in such converting	Persons, groups, or organizations that generate electricity, refine oil, or prepare raw materials for educational equipment and buildings to be used in the system; tools, machines, and other artifacts used in such converting
Producer	Teacher or other person who makes or repairs equipment, or who performs a chemistry experiment or cooks food for the class; teacher or paraprofessional who gives first aid to student; artifacts used to do these things, such as tools, bandages	Cooks; school nurses; maintenance personnel; artifacts like stoves, cooking utensils, tools	Persons, groups, or organizations that manufacture or maintain educational equipment and facilities for the system; nurses and doctors in system; artifacts such as manufacturing machines, tools, or medical supplies used for this	Persons, groups, or organizations that manufacture or maintain educational equipment and other facilities for the system; artifacts such as manufacturing machines, tools, or medical supplies used for this
Matter-Energy Storage	Person who stores educational equipment, or supplies of food, fuel, or first aid supplies; artifacts such as closets, cupboards, or bins for such storage	Storekeeper who stores supplies and food; nurse who stores surgical equipment; maintenance and buildings and grounds staffs that store general equipment; artifacts like closets, store rooms, shelves, containers, parking lot	Persons, groups, or organizations that store supplies, equipment, fuels, electricity, and other essentials for the system; warehouses, tools, storage rooms, batteries, and other storage artifacts	Persons, groups, or organizations that store supplies, equipment, fuels, electricity, and other essentials for the system; warehouses, tools, storage rooms, batteries, and other storage artifacts
Extruder	Person who waste or trash out of classroom person who directs or forces a student or someone else in classroom to leave; teacher who passes or fails student so he or she leaves class; artifacts like waste basket	College officials who graduate or fail students; persons who put out garbage or trash; maintenance men; artifacts like trash or garbage cans, brooms, dump trucks	Persons, groups, or organizations that dispose of wastes, trash, sewage and garbage of the system; that remove persons from its buildings, discharge employees, that graduate or fail students; artifacts like vehicles, sewers, smokestacks, and other equipment used for this	Persons, groups, or organizations that dispose of wastes, trash, sewage, and garbage of the system; that remove persons from its buildings, discharge employees; that graduate or fail students; artifacts like vehicles, sewers, smokestacks, and other equipment used for this

Table 2
(cont.)

Level / Critical Subsystem	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Motor	Person who transports class to or from classroom or moves it to some other location; bus or other artifacts used to convey the class	Drivers of college buses or trucks; artifacts such as cars, buses, trucks	Persons, groups, or organizations that operate vehicles used by system to move facilities or components of system; airplanes, ships, trucks, railroads, or other artifacts used in such movements	Persons, groups, or organizations that operate vehicles used by system to move facilities or components of system; airplanes, ships, trucks, railroads, or other artifacts used in such movements
Supporter	Persons who build and maintain the classroom and its furniture; artifacts such as the room itself and its furniture	Construction workers who build or alter school buildings, or landscape its grounds and build its walks and roads; artifacts such as school buildings and grounds, walks, roads	Persons, groups, and organizations that build and maintain buildings, platforms, and other facilities as well as maintain its land; artifacts such as tools, machines used in these processes	Persons, groups, and organizations that build and maintain buildings, platforms, and other facilities as well as maintain its land; artifacts such as tools, machines used in these processes
Input Transducer	Teacher, paraprofessional, or at times student who brings information to class in spoken or written form; artifacts such as books, journals, radio, TV, or equipment of other media that input information	Guards, telephone operators, mail clerks, public relations office; board of trustees; administrators; faculty members; students; library acquisition staffs; collectors of tuition and fees; artifacts such as mail boxes, telephone equipment, TV and radio receivers; cash boxes, safes	Persons, groups, or organizations that bring into system educational and curricular information, facts about the nation and the entire world; artifacts for conveying or receiving such information, such as books, journals TV and radio receivers	Persons, groups, and organizations that bring into system educational and curricular information, facts about the supranational system and the entire world; artifacts for conveying or receiving such information, such as books, journals, TV and radio receivers

Table 2
(cont.)

Level / Critical Subsystem	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Internal Transducer	One or more members of class who are spokesman for some or all students, reporting what they feel, think, or are doing; artifacts like writing materials used to make such reports	Persons or units of school which make reports to supervisors; committees of students, teachers, and administrators; department heads; bookkeepers, controller's office, payroll department, accountants; artifacts such as computer used for compiling management information, business machines, telephones, typewriters, other writing materials, closed-circuit TV, time clock, suggestion box	Persons, groups, and organizations that make reports to superiors about internal affairs of system; persons providing feedbacks from students and teachers on system operations; regional delegates who vote on system; artifacts such as computers used for compiling management information, business machines, telephones, typewriters, other writing materials	Persons, groups, and organizations that make reports to superiors about internal affairs of the system; feedbacks from students and teachers on the system's operations; national delegates who vote on system policies; computers used for compiling management information
Channel and Net	Each group member who communicates with one or more other members by speech, gesture, or writing; artifacts such as audiovisual aids, books, slide projectors, paper, pencils, pens, chalk, blackboards, used in this communication	Administrators; telephone operators; communications maintenance men; secretaries; faculty and staff members; students; artifacts like books, slide projectors, paper, pencils, pens, chalk, blackboards, telephones, closed-circuit TV	Persons, groups, or organizations that operate and act as nodes in national communications facilities used for educational purposes, such as the mails, radio, TV, telephone, banks and financial institutions; artifacts used in such processes, like wires, cables, satellites	Persons, groups, or organizations that operate and act as nodes in international telecommunications used for educational purposes, such as the mails, radio, TV, telephone, telegraph, international monitary exchanges; artifacts used in such processes, like wires, cables, satellites
Decoder	Person who translates from one language to another, or from written to spoken speech or vice versa, or explains meaning of words; artifacts such as dictionaries that assist decoding	Persons who prepare reports on technical and other difficult topics, putting their contents into simple terms for students or others; persons who translate from one language to another; artifacts such as dictionaries	Persons, groups, or organizations that translate educational materials and communications from one language to another, or into simple terms	Persons, groups, or organizations that translate educational materials and communications from one language to another, or into simple words for students or poorly educated; artifacts like writing equipment used for this purpose

Table 2
(cont.)

Level / Critical Subsystem	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Associator	Students who learn to combine bits of information into knowledge or skills; teachers or paraprofessionals who help them or who learn how best to arrange class procedures; artifacts like books, journals, projectors, teaching machines, TV sets, computers, computer terminals used in such associating processes	Administrators, curriculum planners, teachers who assist students in learning or develop school procedures; artifacts like books, journals, projectors, teaching machines, TV sets, computers, computer terminals used in such associating processes	Officials, groups, or organizations that learn from previous experiences of system and feedbacks from its components and environment, and consequently alter its structure, policy, and procedures	Officials, groups, or organizations that learn from previous experiences of system and feedbacks from its components and environment, and consequently alter its structure, policy, and procedures
Memory	Teachers, paraprofessionals, students, who remember information; artifacts that store information such as books, journals, maps, pictures, charts, files	File clerks, bookkeepers; secretaries, librarians; computer experts; artifacts that store information such as books, journals, maps, pictures, charts, files, libraries, data banks, computers	Persons, groups, or organizations that maintain for the system archives, files, libraries, data banks, sets of instructional materials, or who remember facts relevant to the system; artifacts they use, like files, books, journals, book shelves, computers	Persons, groups, or organizations that maintain for the system archives, files, libraries, data banks, sets of instructional materials, or who remember facts relevant to the system; artifacts they use, like files, books, journals, book shelves, computers
Decider	Teacher, paraprofessional, and in some classes, student or students who determine what the class does; artifacts such as pencils, pens, paper, chalk, blackboards used by teacher, paraprofessional, or students in decision-making processes	Board of trustees; principal; department heads, some students, secretaries, staff members; artifacts such as writing materials, blackboards, chalk, computers, calculators, abacuses	System executives and their staffs; policy-making boards and committees; also may be decentralized to teachers and other personnel in system throughout the country	System executives and their staffs; international representatives, policy-making boards and committees; also may be decentralized to teachers and other personnel in system in different countries

Table 2
(cont.)

Critical Subsystem \ Level	Group (Class)	Organization (School)	Society (National Formal and Nonformal Educational System)	Supranational System (International System for Sharing Resources Among Countries for Formal and Nonformal Education)
Encoder	Teacher, paraprofessional, student or students; artifacts such as dictionaries, pens, pencils, paper, other writing materials	Chairman of board of trustees, principal, department heads; some teachers; artifacts such as dictionaries, paper, pencils, pens, typewriters, duplicators	Persons, groups, or organizations that prepare official publications and reports of the system, like catalogs; writers who prepare speeches for spokesmen; spokesmen and public information officers; artifacts they use, like paper, duplicators, typewriters	Persons, groups, or organizations that prepare official publications and reports of the system, like catalogs; writers who prepare speeches for spokesmen; spokesmen and public information officers; artifacts they use, like paper, duplicators, typewriters
Output Transducer	Teacher, paraprofessional, student or students or graduates of class who make written or oral reports for or about the class; artifacts like typewriters, public address system, paper, pens, pencils	Educational administrator, teacher, or other spokesman who speaks officially for the school; business officer that pays its bills; graduates of school; artifacts such as typewriters, microphones, radio or TV equipment, public address system, printing presses, duplicators, mailing equipment used in making or issuing reports	Spokesman for national system, such as Minister of Education; operators of educational broadcast media; typists and printers who put out reports from system; graduates from system; artifacts like TV equipment, printing press, microphone, journals used in making reports	Spokesmen for international system; operators of international educational broadcast media; typists and printers who put out reports from system; graduates from system; artifacts like TV equipment, printing press, microphone, journals used in making reports

Table 2. The Educational System (*i.e.*, Associator Subsystem) of Each of Four Levels: Group (a Class); Organization (a School); Society (a National Educational System); and Supranational System (an International Educational System).

4. Level of the Group:
The Class or Tutorial Session

Ordinarily the fundamental educational process is face-to-face--the simplest form being the tutorial relationship of one teacher or counselor and one pupil, Mark Hopkins on one end of a log and the student on the other. More typically there is one teacher and 20 to 30 students, a classroom. The classroom is made of walls, floors, and ceilings, material artifacts which constitute the supporter subsystem of the group who study in it. In and out of the classroom matter must flow--students, teachers, school books, the hardware of audiovisual aids, other supplies--and so must energy--heat and light. These flows change over time. But the most important flows in a classroom are information flows--the information in the books, on the television sets, and in the interactions between the students and the teacher. These information transmissions are integral to the fundamental learning process. They also are the means whereby the teacher maintains discipline and coordinates the students who are components in the concrete living system which is the class.

The spatial structure of the class importantly influences its processes. If students are seated at desks facing the blackboards or television set, their interactions are different than if they are arranged in a circle or if they are stationed at laboratory benches. The classroom process varies also with the content of the information discussed and the teacher's approach to interpersonal reactions, which is often dictated by the teacher's philosophy of education.

Group learning situations differ in type: some are lecture sections, some discussions, some laboratories, some field trips, and some are extracurricular or nonformal groups. The typical class is a face-to-face group and so it does not have echelons, but occasionally a large class organizes into echelons. The suprasystem of the class is an organization, the school, and its subsystem is the individual student or teacher.

Within the class there are numerous sorts of transmissions. Matter-energy such as laboratory equipment, experimental animals, or chemicals may be distributed to all the students. Information is processed when the teacher asks questions and the students respond, when the teacher writes problems on the blackboard and students solve them on their papers.

Also various sorts of steady states are maintained by the class. Ordinarily the teacher exerts the dominant control of these. With the help of the bell and the clock which signal the times for class periods, the teacher determines when the class begins and ends. The teacher usually divides the time available to the class more or less equally among the students, recognizing who is to speak, keeping the entire class in adjustment by urging some students to talk more and quieting those students who speak too much or out of turn.

Often the teacher varies the rate of information processing, sensitively reacting to signals in the students' expressions and comments, which indicate how fast and well they are learning. A new topic is not taken up until most of the class have mastered the previous one.

Usually the teacher wields the primary power in the class, but often, as the students get older and enter the higher grades, this power is diminished. Sometimes students resolve conflicts among themselves, but often the teacher must step in as the decider in the group. The teacher is trained to understand the overall purposes of the course being taught and to set day-to-day and moment-to-moment goals to accomplish these purposes.

Of course there are significant costs in the functioning of any class. First there are the original capital costs of building the classroom. There are the operating costs of light, heat, supplies, and repairs. There are also the costs of recruiting, training, and equipping the teacher and of the information-processing media which bring information to the class. There is the salary of the teacher and any paraprofessionals, administrators, or staff. Besides the money expended there are also costs in human time which is spent at the school. Since it is possible to evaluate, at least roughly, the effectiveness of a single hour in class or a single course, cost-effectiveness evaluations of a specific class are possible.

What are the critical subsystems of the living system known as the class? The student who holds open the classroom door so others can enter or goes out to call in his fellow students at the beginning of class is part of the ingestor. The teacher or child who distributes fruit or milk in kindergarten is part of the distributor. The assistant responsible for the stock of glassware and chemical reagents in a high school laboratory is part of the matter-energy storage subsystem. The student who opens a window or door when the class gets too hot is part of the extruder.

The information processing subsystems are more central to the main purposes of any educational group. The child who comes in and reports on his experiences over the weekend in "Show and Tell" is a component of

the input transducer. The girl who reports that the boy behind her is sticking her with a pencil is part of the internal transducer. The channel and net includes air through which the students talk as well as the examination papers they hand in to the teacher. Often the teacher alone is the decider, but at times some or all students may join with the teacher in this group process. The report from the teacher to the principal on how the class did that week is an output transducer function.

All the above concerns formal educational groups. More education is nonformal than formal. In a few cases nonformal education may occur in groups, as in families, youth groups, or community groups in a village square. Such groups make some sort of rough delegation of functions like those of traditional classes, but their structure is more changeable and looser. Those with access to the information, the older or more experienced, in general control the group and inform the younger or less experienced. Much nonformal education, of course, goes on in individual persons working independently.

5. Level of the Organization: The School, College, or University

5.1 The school. A school is a system whose components or subcomponents are classes in classrooms, administrators in offices, workers in storage areas, cooks and waitresses in cafeterias, and maintenance personnel throughout. It is usually part of a school system, which is its suprasystem.

Schools are open systems into which resources and people--students and employees--come and from which students graduate and the employees leave after a period of time. The processes which a school purposes to bring

about are irreversible learning processes. A school is in some ways like a job shop in which students are processed from station to station, from one learning experience to another. The experiences of various students are similar but not identical. Nor are their order and timing identical. If a school succeeds in individualizing instruction, a student's behavioral and cognitive changes are the key determiner of the timing.

A school is generally housed in a supporter subsystem artifact--a building or a set of buildings on some real estate, all together occupying physical space. This physical space is important because it limits expansion and restricts the size of auxiliary facilities such as football fields and playgrounds. Building a school alters arrangements in physical space, but it also changes the spaces of abstracted systems in which it is located, e.g., community structure or relationships. It becomes the locus of many community activities, such as the Parent-Teachers Association which allow citizens to cooperate for the purpose of helping the school. It allows certain members of the community to exercise initiative and leadership and derive a variety of benefits from that kind of participation. It also becomes the center of a political unit for those persons who are concerned with financial and other support of that school. It affects real estate values in its immediate surroundings.

Time is a fundamental dimension in schools. In some an established procedure of ringing bells divides time into regular segments and indicates the limits of class periods. The class programs and major activities are scheduled in terms of the days in a school year calendar. One recent change in many schools has been flexible scheduling, based on the developments in

individual classes. The availability of media, the use of closed circuit and broadcast educational television has added more flexibility to some aspects of school processes but more rigidity to others which are dependent on the timing of broadcasts. The more individualized instruction with books, cassettes, or dial-access tape laboratories that is available, the more flexible can the scheduling and operation of the school be.

In common with most other organizations schools process matter-energy. As any school principal knows, planning about matter-energy structures and processes comes first whenever any new school is being constructed. The architect designs the walls, floors, roof, and other parts of the building and the contractor constructs it from those plans. Fuel is commonly brought in to provide heat when it is cold and, in some parts of the world, electricity to provide light and power. There are also often inputs of water, food, equipment, and other supplies and outputs of garbage and sewage. Over time students come and students go.

Information transactions, however, are the main business of a school. In addition to the direct information interactions which occur between teacher and student, the administration and operation of the school as a whole require many types of information flows. Operational information is needed to coordinate and plan the educational process. Information is collected on such matters as pupil attendance. Such data are important as operational indices and for fiscal and administrative purposes, since in many schools, the amount of revenue received depends on them. Payroll information must also be collected. Additional information is necessary for scheduling programs of students, teachers, and facilities.

All the variables in a school are never in steady state. Adjustment processes reacting to negative feedbacks are continuously active. Feedbacks occur within the school in many channels between the principal, the teachers, and the students, as well as the parents and the citizens of the community. Numerous adjustment processes are required to keep the school operating under these many forces.

In one-room schools the teacher is the chief decider. In larger schools power and conflict are critical problems. In many of them today, decision-making power is chiefly wielded by the teachers. The principals or other administrators are faced with the difficult position of being expected to resolve conflicts and bring about decisions to keep the system integrated, which concern teachers, over whom they have little control because of their tenure, teachers' unions, schoolwide curricular decisions, and a suprasystem which makes the decisions allocating major resources. Often the principal feels that he is little more than the school's output transducer--a public relations man. Of course, in small schools, or independent ones, the principal or headmaster may be the key power figure. Conflicts also occur between outside and inside groups such as unions and faculties. Conflicts also occur inside schools between students and teachers. Interpersonal conflicts within the staff have always existed.

The purposes and goals of a given school relate to the overall plan of its suprasystem, the school system. Individual schools are expected to apply their resources to maximize the educational objectives set forth by the school system. Typically these purposes and goals, of quite different sorts, may

be divided into: (a) educational objectives, such as preparing a student for a vocational school, teaching vocational skills, preparing a student for college; (b) social skills, such as good citizenship, developing good consumers and responsible citizens; (c) economic service objectives, such as keeping the students off the streets, babysitting for working mothers, and other such activities; and (d) community services, such as PTA or nonformal educational programs in the late afternoons or evenings, and weekends. The physical plant is often used by the community also, for recreation and entertainment, for sports, movies or plays.

Costs of a school include use or expenditure of scarce resources such as materials--foods, equipment, supplies; energy--light, heat, fuel; information--books, audiovisual and other instructional aids; budgeted funds; human time of all personnel in the school and many in the community. When these inputs are measured and compared with output measures of achievement of purposes and goals, cost-effectiveness evaluation of a given school is at least roughly possible. Effectiveness can be measured in terms of the number of students who graduate, the number who go to college, the number who drop out, how well students do in competitive examinations, how well they do in getting and holding jobs, measure of changed attitudes and behavior, crime rates among students and graduates, and other indices of undesired social conditions among them, such as narcotics addiction, ill health, or poor housing.

The critical subsystems of a school may include guards who protect and maintain the boundary; the admissions office whose personnel register new students and so are components of the ingestor; workmen who cart equipment to various rooms in the school, parts of the distributor; the

cooks in the cafeteria, components of the converter and the producer; the bookstore clerk, part of the matter-energy storage subsystem; and the janitor, a component of the extruder. As to the information processing subsystems, the student, teacher, or the technician who operates the educational television controls is a unit of the input transducer; the teachers, paraprofessionals, administrators, and students all participate in the channel and net; the librarian is part of the memory; the principal and teachers jointly constitute the decider, with the principal more in control in some cases and the teachers more in control in others; and the principal and often the teachers are major components of the output transducer.

5.2 The college. A college is a concrete living system with a structure usually clearly pictured in maps of the college. The process in that structure is often vigorous and always complex.

There are various types of colleges, classed by the content they study--e.g., general education, engineering, or law--by number of components, and by form of organization. The suprasystem of some colleges is a university. For independent colleges it is the community of which they are a part. The components are departments, usually representing separate academic disciplines, and other units such as student unions, fraternities, dormitories, and field stations.

A college has as its territory the campus. Within its boundary are arranged clusters of matter which are its buildings. Into this campus enter many forms of nonliving and living matter--bricks and mortar, furniture, equipment, supplies, food, automobiles, bicycles. Also animals and human

beings enter. And there are outputs of such things as well; some, like the graduates, are the products of the system. Others are wastes. All the structural configurations and processes of input and output change over time. This change may be slow, for many colleges are traditional. They often endure a long time. Some European colleges are centuries old. Even in America Harvard College has lasted more than three centuries and Yale for nearly three.

As at all other levels of educational systems, the types of processes which are most important and characteristic and which chiefly accomplish the purposes and goals of the system are the information processes. Information flows into a college from all over the world--by scholarly journals, books, radio, television, the mails, but also by visiting scholars, students, and others who come there for varying lengths of time. There are many patterns of information communication and storage within the system. These include interactions among students and faculty, learning by faculty and students, storage of memories in human beings and libraries, and publication of knowledge through books, broadcasts, and travel of professors and graduates to all parts of the world.

Some colleges, like a Jesuit seminary or a school of agriculture and mining, are quite clear about their purposes. Others, particularly those concerned with general education and the humanities, are less certain. Nevertheless, they appear to set goals which lead toward certain purposes, vaguely or clearly outlined.

Any faculty member or administrator of a college who has ever made a budget knows that all the college's processes involve costs in matter-energy, information, and time of the human beings involved. Consequently it is possible

to make cost-effectiveness evaluations of how well the system is achieving its long-range purposes and its short-range goals. The measurement of effectiveness of such a system is by no means easy because the organization's purposes and goals are subtle. Much thought has been given to this problem of evaluation, however, and this effort has resulted in some progress.

It is not hard to identify the critical subsystems of a college. The police who guard it are involved in its boundary subsystem. Those who bring in the necessary books, supplies, fuel, and food are parts of its ingestor, and the drivers of the delivery trucks and porters who take such things to all parts of its campus are components of its distributor. In closets, pantries, and bookstores it has matter-energy storage. The cooks, heating engineers, and carpenters are components of its converter and producer. The drivers of the trucks that remove the wastes are parts of the extruder.

In the information processing subsystems the Dean of Admissions and the mail clerks are parts of the input transducer. The Dean of Student Affairs does much of the internal transducing, learning how the students feel about various aspects of their college life. Both students and teachers are involved in learning and are components of the associator. The scholars and librarians are parts of the memory. The department chairmen, deans, and presidents help to make up the decider. The administration of the college uses its power to maintain the appropriate adjustments between the students' demands for power and accomplishment, the faculty's demands, and the demands of the other components in the total system. The officers of administration constitute a major component of the decider, which may often be dispersed to include others as well. They make their decisions in the light of many

feedbacks which they receive from all parts of the system and its environment. Often they find themselves involved in the resolutions of interpersonal and intergroup conflicts.

The administration also is a chief component of the output transducer. With cooperation of many other components, it maintains a steady state relationship between the system and the suprasystem, through public statements and press releases, and various interactions with the alumni and citizens of the community. The faculty who publish and go forth to lecture, as well as the trustees, are also components of the output transducer.

Nonformal higher education by correspondence courses, home study, and television has expanded as the concept of lifetime learning has received increased currency in both established and less developed countries. This is conducted in a more flexible structure than that of a typical college described above. Students of all ages are accepted; prerequisites are often waived; examinations sometimes replace courses; students do not follow fixed time schedules. But the processes of the system are in other ways usually much the same.

5.3 The university. Obviously a university is not fundamentally different from a college as a living system. It is usually larger, more variegated, more sophisticated. Because of their size and variety, as universities have grown from colleges they have developed more and more echelons. Some colleges have only department chairmen and a president. But long ago deans intervened over department chairmen, and in the last 20 to 30 years provosts, chancellors, vice chancellors, and vice presidents

have also flourished. Academic structures have become much more complex with components, subcomponents, and subsubcomponents--colleges, departments, and units of departments, as well as institutes, centers, and intercollege programs.

As the systems have grown in size and complexity, decision processes have been decentralized and the systems have demonstrated less integration. The major programs or components usually represent content areas or disciplines--categories of information processed--instead of functions, which components almost always represent in large industrial or governmental organizations. Although the boundaries of university departments at first are often set by subtle academic logic, and so surround abstracted systems, eventually the different components so separated grow into semi-autonomous concrete systems--groups of people.

Management information systems are being used for the first time in recent years to evaluate the cost and effectiveness of programs of higher education. The costs are easier to determine than the effectiveness, but to some extent arbitrary criteria have been set up, like the national ratings of the quality of graduate departments, the number of their publications, or the number of their graduates who pass professional examinations. These measures, though subject to criticism and clearly unsophisticated, are first steps toward more reliable effectiveness evaluation.

The critical subsystems of universities are similar to those of colleges. The main difference is that the decider subsystem is much more decentralized.

Nonformal education is beginning to flourish around the world in universities as well as colleges. The British Open University, imitated in several other countries is the paradigm.

6. Level of the Organization (Higher Echelons): The School System or Statewide Educational Agency

The structure of a school system or statewide educational system is much more complex than that of a school, college, or some universities. Some decisions are centralized and others are decentralized. Some very large systems have several hierarchical echelons. The processes involved are those of planning, control, training, logistics, acquisition of educational materials, and development of common services to serve all components of the system.

The suprasystem is the community or the state. Altogether these higher echelon educational organizations constitute a major part of the associator subsystem of the community or state--at least the formal part of it.

The matter and energy of a school system or statewide educational agency include all matter-energy in the organizations which are its components and their artifacts. In addition there are school bus transportation facilities, warehousing and shipping facilities, and other services which use the roads of the community or state, which is the suprasystem of the system. Time takes a new perspective as compared with the school's time units of hours, weeks, and the school year. A school system works in terms of several years. A bond issue or a governmental appropriation and a consequent commitment to buy land and build on it is a multiple-year activity. Planning-programming-budgeting (PPB) for school systems always requires a multiple-year plan.

Information processing also is essential if personnel, facilities, and allocated resources are to be kept under control and coordinated. Resource allocation and control are major functions of a school system or statewide educational agency. Individual institutions in the system need monetary inputs and generate the flows of administrative information that lead to more such inputs. The school board, state secretariat of education or regents, with their ability to propose bond issues and to request or help determine tax levies, gets involved in many political processes in the decider subsystem of the community or state. All these processes must be coordinated by information flows into and out of the system.

There are matter-energy flows of supplies and equipment and of persons among components of school systems or statewide educational systems. Information flows, usually over the community channel and net subsystem, are much more fundamental. They provide feedbacks and control signals which maintain the adjustment processes that keep components of the system in steady states in relation to each other and to the rest of the community or state. Information is processed about votes and bond issues, levies, the effect of the press, and public sentiments about the educational system. Many school systems have shown great interest in developing instruments to measure how they are viewed by the public (input transducer activity) and in public relations (output transducer activity).

Power and conflict problems are much greater in the school systems (or statewide agencies) level than in schools. Internal discussions about such systems also intimately involve issues of power in the suprasystem of which they are a part--community and state governments, citizens' groups, real estate interests, and political organizations, among others.

The purposes and goals of a higher echelon education system are ordinarily expected to be achieved over a longer time span than purposes of a school. Five years is the minimal planning period for the education of a cohort of students in established or less developed nations. Often it is ten years or more. A time span of seven years is minimal for such planning as the decision to buy buses, because seven years is the average life of school buses. Land buying commitments involve planning many years ahead, since bond issues or public financing may take 20, 30, or 50 years to retire.

The purposes of such educational systems include giving quality education to all citizens through programs which meet their individual needs, including special groups like illiterates, children with physical disabilities or learning disabilities, adults who have dropped out of school or who have not learned an occupation. These purposes may be achieved by accomplishing specific goals like operating special education classes, an educational television station, a vocational school, or a nonformal education program for illiterate adults.

Cost-effectiveness evaluations are of great potential value to higher echelon educational organizations because a maximal possible level of expenditure exists at any given time, and the system should try to achieve the optimal ratio of costs and benefits for that level of resources. It is difficult to finance outstanding programs when inflation, increasing salaries, and other pressures exert continuing financial pressures on the system, sometimes even in spite of additional revenues. These problems may lead

the system to develop a PPB accounting system. This can facilitate presenting program alternative with meaningful cost projects to the officials responsible for making decisions about the best allocation of resources to accomplish their goals.

The critical subsystems of a higher echelon educational system include: Guards and community police that protect the boundaries of its properties. Warehouse personnel that receive shipments of fuels, furniture, and equipment, components of its ingestor. Truckers who deliver such supplies to component institutions, parts of its distributor. Persons who build or manufacture supplies, part of its converter and producer. Warehouse laborers, parts of its matter-energy storage. And bus drivers, components of its motor.

Closer to the system's primary purposes are the subsystems that process information, including administrators who bring back from national or international conventions reports on what other similar systems are doing, components of the input transducer. Administrators who receive periodic reports from each institution in the system, part of the internal transducer. Telephone operators, parts of the channel and net. Filing clerks, parts of the memory. The board and top administrators, parts of the decider. And the chairman of the board or the chief administrator or public relations officer, parts of the output transducer.

7. Level of the Society:
The Nation's Educational System

Countries vary greatly in the structures of their associator subsystem, made up of the components responsible for education. Formal education in most other nations, as we have noted, is much more centralized than in the

United States. The components of the elementary, secondary, and higher education of the United States have been described above. The national educational system is simply the sum total of these plus the administrators who determine policy for it, like the Office of Education, acting as interfaces between it and the total nation.

The national educational system of the United States has few operating units beyond those mentioned above. Consequently the main emphasis in discussing this level of national educational system will concern how decisions are made in it. Day-to-day decisions in individual schools of course are made by its principal and teachers. Superintendents in schools and boards of education are probably the most autonomous decision-making units in elementary and secondary education, just as college and university administrators and boards of trustees are autonomous decision-making units in higher education. State superintendents of education have been relatively impotent so far, and until the last few years statewide controlling boards of higher education have not been powerful deciders, but the balance of power is rapidly changing from the colleges and universities to the administrators of statewide systems, including the governor and the legislature.

The United States Office of Education has been relatively impotent until this decade, but its decision-making power has grown in the Kennedy, Johnson, and Nixon administrations. It is still much less influential in elementary and secondary education than in higher education, although the balance is shifting. The fundamental influence in the Office of Education is through the funds it administers for building construction, educational

subsidies, student loans and grants, educational research, and educational technologies. As it gained this financial power the prestige and decision-making power of the national educational organization has increased dramatically. Through the networks of official communications channels and through professional conventions, local school boards and college boards of trustees are affected by national decision-makers. The granting processes of federal agencies and foundations--including the new National Institute of Education--have also become important aspects of the decision-making process. Now, for the first time, it begins to be possible to plan such institutions as national resource centers to provide curricular materials for various media, as well as national electronic networks for educational purposes. When these begin to function, not only decision making but also the education process itself is likely to become more centralized nationally.

The organization structure of most of the less developed nations is quite different. The Minister of Education usually has much more power to make policy and budgetary decisions than any federal official in the United States. The Secretaries of Education in the various states or regions are permitted some discretion under broad directives, and they in turn permit more restricted discretion to administrators at lower echelons of the national system. In some countries educational programs emphasize regional and local languages, customs, and cultures. In others such regionalism is muted by a strong emphasis on nationalistic educational themes.

In many less developed nations it is apparent that the formal educational system cannot in the near future begin to meet the educational needs of the children or the adults. Nonformal mass education, probably using the information processing technologies, appears to be the only feasible approach to a solution.

8. Level of the Supranational System: The International Educational System

Except for the interchange of publications among nations for Fulbright, Guggenheim, and other visiting fellowships and scholarships, the educational systems of the world's nations have been almost entirely independent of each other and still are. With the establishment of the League of Nations and more recently of the United Nations--and particularly with UNESCO related to the United Nations--there is some worldwide planning and mutual assistance for education. Several major nations and multinational agencies are providing financial aid and technical advice in this field to less developed nations.

Someday there may be an international or supranational educational system with a multinational decider, but we are far from it at present. Educators are communicating regularly by publications, international congresses, and international consultation. The educational leaders of nations know each other and intercommunicate to a degree. The first steps have been taken toward the development of international textbooks and television lectures, and the setting up by satellites of international channels and networks interconnecting the national educational systems of the world. There may well be rapid development of these technologies and consequently of the decision-making process required to coordinate them. As of now, however, the international educational system is not a true system, since there is no effective central decider. There are only vestiges which may sometime grow into a potent means for teaching the citizens of the world and hopefully aiding them to live together in harmony.

9. The Standard Procedures of Systems Analysis and Evaluation

At all these levels of educational systems, in recent years, efforts at systems analysis and evaluation are getting under way. Often these are holting, imprecise, and amateurish. But increasingly educators are coming to recognize their need for such activities and they are gradually becoming more sophisticated about these procedures and how they can be used to make policy decisions selecting among alternative educational strategies. In a recent book Banghart has made a clear exposition of how systems analysis and evaluation can be applied to educational programs.[1]

"The methodology of systems analysis has been based primarily upon mathematics. The true contribution of systems procedures has rested with the ability of the analyst to quantify his concepts and derive solutions from that quantification. Because of the quantitative orientation of systems analysts, there has been some historical confusion between systems analysis and operations research....

"The field of operations research has become almost exclusively mathematically oriented. Indeed, it could be considered a subset of mathematical analysis. Systems analysis on the other hand embraces qualitative as well as quantitative techniques. A systems analysis attempts to look at the total operating organization in the beginning even though eventually the analysis is done upon some component subsystem. The invariant factor common to both systems analysis and operations research is the scientific orientation that both bring to bear upon management problems....

"There is a series of steps through which one must proceed in order to accomplish a systems analysis....

"Step One - Establish Objectives. The most difficult part of the entire systems study involves establishment of very specific objectives to be accomplished. Because of the quantitative nature of systems analysis, it is necessary to be extremely specific in determining the objectives to be achieved. To state objectives in general terms such as improvement of curriculum, enhancement of the educational system, or development of a better building program is totally inadequate. To list the re-evaluation of the fiscal system as an objective, for instance, would be inappropriate. A systems study would entail automating the fiscal procedures. Cost benefit analysis would be used. Staff utilization and flow charting would complete the fiscal system by stipulating the details of all fiscal functions involved in the total school system.

"Step Two - Review of Systems Operations. The second step in systems analysis involves a comprehensive review of all the systems operations. Since systems analysis is problem oriented, one does not always perform the analysis on the total operation. It is, however, necessary to understand completely the systems operations before one can thoroughly delineate the problem to be studied. It is almost a truism in education as in industry that the problem which the administrator feels to be the main problem does not always turn out to be the main problem. Under any circumstances a systematic review of the total system is necessary in order that the analyst can understand the setting in which the problem to be solved rests.

"Step Three - Collection of Data. Following review of the total system and isolation of the apparent problem area, the analyst begins to collect detailed data within the problem area. At this point, the system analyst diverges from the traditional way of administrative decision making. Traditional in the sense that one reviews operations and makes intuitive judgments from the review. Collection of data involves basically a statistical procedure....

"Step Four - The Analysis of Data. Analysis of data is discussed separately from collection of data in order to point out the distinction between a systems analysis and the traditional experimental paradigm in research. The experimenter in the social sciences has generally followed the model of the physicist. That is, his experiment involves a dependent and an independent variable. Manipulation of the independent variable is followed by systematic measurements made upon the dependent variable. In classical fashion cause and effect relationships are studied and determined. This type of classical experimental paradigm, however, assumes that the investigator knows in advance specifically which variables are to be controlled and investigated. In a systems analysis one begins the analysis with the objective of determining just which variables are relevant. Where the classical experimenter is concerned with manipulation of variables in the dependent and independent sense, the analyst is concerned with a study dealing with interaction of many variables. Causality is not necessarily the primary concern. Correlation becomes the primary concern.

"Step Five - Isolation of the Problem. As indicated earlier, the administrator does not always know precisely what the problem is. It is necessary to go through the systematic review, data collection, and analysis of data in order to determine the specific problem. Isolation of the problem then follows the sequence of steps that allows one to spell out in precise detail the nature of the problem. Although systems analysis is a comprehensive concept and one which begins with the big picture, the techniques are essentially problem oriented and require isolation, specificity, and definition of the problem.

"Step Six - Specify Operations in the Problem Area. Once the specific problem has been isolated, it is necessary to do a detailed comprehensive review of those operations within the problem area. This review is much more detailed than the original review of the total operations. One, in effect, builds a detailed model of the problem area operations in order to understand quickly the relationship of all facets of the problem area to the total operating system.

"Step Seven - Block Diagram. The problem area has a final step in the analytical stages of the systems analysis. Yet, prior to building a new design, one builds a block diagram of all functions of the subsystem that makes up the problem area. This block diagram is based upon the prior model, which is an outgrowth of the analysis of specific operations in the problem area. The block diagram denotes logical structure of the subsystem operations....

"After the system analysis the analyst attempts to design a tentative solution to the problem. Before any implementation of the new solution is made, that new solution is subjected to testing. Following the test, necessary corrections are made to the tentative solution, and the modified tentative solution is again subjected to tests. This loop consisting of a tentative solution, testing the tentative solution, modifying the tentative solution, and retesting the tentative solution continues until the analyst converges upon an optimal solution. Once the optimal solution is found, the analyst departs from that loop....

"The formal evaluation of the new solution follows essentially the same loop that the small testing procedures followed in checking out the tentative solution. The primary difference between the formal evaluation may involve (and usually will) implementation of the tentative solution in some aspect of the system. As the formal evaluation proceeds, modifications are made to the operating system, reevaluations are made, new modifications are made, and once again the analyst proceeds through the same type of loop indicated earlier. Not all evaluations are made in actual operational trials. Many are conducted through simulation. However, at this stage it is probably advisable to test out or evaluate all new system solutions in a small segment of the required operation....

"Once the new system is in operation an inherent part of system procedures involves continuous monitoring of the system in order to check on the effectiveness of the system. The objective of this

continuous monitoring is to detect less than optimal functions of the system and in this fashion make improvements upon the new system. In effect the system monitor continues the basic philosophy of a systems study. It affords the administrator an opportunity to constantly analyze the system, make new tentative designs for improvement of the system, evalute improvements and old functions of the system, and operate and maintain the system....

"Any systems evaluation scheme must include at least the following four general categories: performance, cost, utility, and time. The general criterion is that the total system should operate in an optimal fashion. This means that many suboptimizations and their relations to the total functioning system must be taken into consideration. Frequently, it is discovered that subsystems must function in less than optimal fashion in order that the total system may operate optimally.

"Performance. An evaluation of performance is done in terms of effectiveness. The design of the problem solution determines how effective the new system will be in fulfilling the organization's mission. It is necessary to devise standards for measuring effectiveness. These standards might be derived from norms within or outside the system. One might wish to develop a standard of current operation efficiency and compare the new system with that current standard. Frequently it will be necessary to utilize standards from without the system and bring the system up to the level of outside standards. Throughout the systems study the assumption is made that organizational objectives have been clearly and concisely stipulated....

"Analysis of systems is influenced by cost function to a major extent. The expected outcome of a systems analysis is concerned with the problem of allocation of resources. Although the resources include personnel and facilities in addition to cost, in some fashion one is usually confronted with the problem of allocating fiscal resources or those functions dependent upon fiscal resources. Primary motivation for performing a systems analysis is to furnish the decision maker with a reasonable basis for making the choice among alternatives. The administrator must deliberately train himself in the art of selecting from alternatives and thinking in terms of alternatives. Increasingly technology has made available to the administrator techniques that give him a more solid basis for making decisions or selecting from among alternatives. In order to make decisions on the basis of selection from a clear-cut set of alternatives, one must have comprehensive data about the relevant aspects of the system. For example, if a decision is to be made regarding the feasibility of developing a special education program for students below 80 IQ, there are two basic approaches to making such a decision: (1) The decision can be made on the basis that the need exists. A solution to the problem is desirable on the part of the school officials, the community, and of course the students involved. The question is should the necessary funds be committed to provide facilities and staff and supporing personnel to initiate the program in special education. A judgment could be made on the basis of whether or not the necessary funds are available

to implement the program. An alternative way of making the decision as to whether or not the program is to be implemented is based upon a comprehensive look at the functions of the system. The amount of resources are being put into the system functions in terms of dollars, staff, and facilities. Comparisons are made regarding the investment of resources in the special education program relative to the other functions. On the basis of definitive information regarding current allocation of resources, a decision can be reached as to whether or not a reallocation of resources should be made in order that the special education program can be implemented.

"If decisions are made on the basis of the reallocation of resources, it becomes quite clear to the decision maker that if he is to put resources into a venture, those resources must be transferred from some other function. In this sense then there is a cost function involved in the decision making that extends beyond the mere dollar value of the monies involved. The cost function must be calculated on the basis of comparisons of the new function with those functions which must be abandoned in order that the new function be implemented. Cost analysis, therefore, becomes a somewhat more all-embracing term. The concept of cost involves a combined term of cost utility rather than merely the dollar value involved. Effective costing, therefore, must be thought of in terms of cost utility analysis rather than the mere allocation of dollars. Some clarification of this concept is possible if one thinks in terms of programming as a fixed utility approach, that is, you design your program around a set of priorities and preferences and allocate your resources strictly on the basis of

fixed utility. An alternative approach, also a fixed nature, would be that you plan your program from the approach of a fixed budget. Probably neither of these approaches can be optimal, although the second approach, that is the fixed budget approach, is one used almost universally by budget planners in school systems. That is, the budget is designed around the budget of the prior year with slight additions here and there, based upon what the superintendent believes the traffic will bear for the coming year. A more nearly optimal approach involves combining the dollar amount available for the total budget and specifically spelling out utilities for the various subfunctions. Various procedures have been systematically developed that allow the administrator considerable assistance in the area of costing. These procedures are extremely valuable as a part of criteria for evaluating systems projects. The terms which describe techniques helpful to costing include cost benefit analysis, cost utility, cost effectiveness, and many of the techniques developed in the area of systems analysis....

"The process of allocating resources is determined by the selection of certain courses of action from among various alternatives. Which courses of action are selected will be a function of the relative utility or value of the different alternatives. The ultimate criterion, therefore, is utility, value, or payoff to the system. In this sense education is similar to business. The return on investment represents the utility of a given function....

"Time dimension as an evaluative criterion is closely associated with effectiveness. In terms of accomplishment one is required to look into the relative time requirements for two systems. Time is particularly relevant in evaluating programs....Techniques such as PERT have been designed specifically to furnish management with systematic control of time functions. Allocation of resources is linked closely with time when implementation is the concern."

We now have surveyed briefly the various levels of educational systems and the methods for analyzing them and evaluating the cost effectiveness of various alternative educational strategies. Before we investigate these procedures in detail we must first determine what is the range of altenatives provided to systems planners by the presently available instructional technologies. That is the topic of the next chapter.

Notes and References

1. Banghart, F. W. Educational systems analysis. New York: Macmillan, 1969, 37-46.

CHAPTER III

THE PRESENTLY AVAILABLE INSTRUCTIONAL TECHNOLOGIES

What are the various kinds of instructional technology? In its broadest sense this phrase may refer to any form of learning situation planfully established by an educational system, including a tutorial session, a group conference, a school class, or a large university lecture, as well as the use of a wide range of man-made artifacts. Its more common usage includes all artifacts used as prostheses to aid in the learning process--from chalk to computers. The communication channels and nets which make possible widespread use of these technologies also should be included in any consideration of educational technology--word-of-mouth transmission in human interaction situations, transmission by courier, by the mails, or by telegraph, teletype, telephone, or television lines, microwave, laser, national or international communications satellite.

1. List of the Technologies

Table 3 lists most of the instructional media available today, and states strengths, weaknesses, and costs of each.

The terms which describe the media in this table make clear what they are, with perhaps a few exceptions. The fotonovela, based on photographic comic books, is a series of still pictures assembled to convey simple ideas or stories with little or no text. Rubber stamp

Table 3

Instructional Medium	Can user carry it around?	Can user use it individually at school or college?	Can user use it individually at home?	Can user determine when it is to be used?	Can user control rate of information flow & repeat if not understood?	Can user interact actively with input?	Is individualized "branching" possible	Senses used	Are signals sent on electronic network?	Costs (in dollars per user hour)
1. Tutorial sessions or small group discussions	No	No	No	No	Sometimes	Yes	Rarely	Vision & audition	No	0.50-15
2. Class lectures	No	No	No	No	No	No	No	Vision & audition	NO	0.15-3
3. Lettering, writing on blackboard, charts, flash-cards, flannel boards, diagrams, graphs, maps, fotonovelas, billboards, rubber stamp designs	Often	Yes	Yes	Sometimes	Sometimes	Yes	No	Vision	No	0.01-0.05
4. Stage scenery sets	No	No	No	No	No	No	No	Vision	No	0.01-1
5. Letters, written papers, documents, books, work-books, comic books, tests, programmed textbooks, other printed educational materials, newspapers, journals, pamphlets, computer print-outs, Braille writings, punched paper tape	Yes	Yes	Yes	Yes	Yes	Sometimes	Only with programmed textbooks	Vision	No	0.01-0.05
6. Demonstrations	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	Sometimes	No	Vision & audition	No	0.05-1
7. Dramatizations	No	No	No	No	No	No	No	Vision & audition	No	0.05-5
8. Exhibits	No	Sometimes	No	Yes	Yes	Sometimes	Rarely	Vision & audition	No	0.05-1
9. Field trips	No	No	No	No	Sometimes	Sometimes	No	Vision & audition	No	0.25-5
10. Photographs, filmstrips, film loops, microform	Yes	Yes	Yes	Yes	Yes	No	No	Vision	No	0.01-0.50
11. Teaching machines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Vision & rarely audition	No	0.05-0.15
12. Silent motion pictures	Yes	Sometimes	Rarely	Rarely	No	No	No	Vision	No	0.25-3
13. Filmstrips, film loops, or slides with audio tapes, sound-on-slides, audio flip	Yes	Yes	Yes	Sometimes	Yes	No	No	Vision & audition	No	0.05-1

Table 3 (cont.)

Instructional Medium	Can user carry it around?	Can user use it individually at school or college?	Can user use it individually at home?	Can user determine when it is to be used?	Can user control rate of information flow & repeat if not understood?	Can user interact actively with input?	Is individualized "branching" possible?	Senses used	Are signals sent on electronic network?	Costs (in dollars per user hour)
14. Sound motion pictures	Yes	Sometimes	Rarely	Rarely	No	No	No	Vision & audition	No	0.25-5
15. Telephone	No	Yes	Yes	Yes	Yes	Yes	Yes	Audition	Yes	0.02-1
16. Broadcast live instructional radio	Yes	Yes	Yes	No	No	Yes, if feedback	No	Audition	Yes	0.01-0.50
17. Telewriting, telewritevision	No	No	No	Rarely	No	No	No	Vision	Yes, except only writing for tele-writervision	0.02-1
18. Audio tapes, cassettes, cartridges, records	Yes	Yes	Yes	Yes	Yes	No	No	Audition	Yes	0.02-0.25
19. Dial-access audio tapes	No	Yes	Rarely	Yes	In some systems	Rarely	No	Audition	Yes	0.01-2
20. Teletype, telegraph	No	Yes	No	Yes	Yes	Yes	Yes	Vision	Yes	0.02-1
21. Closed-circuit audio lectures	No	Yes	No	No	No	Yes, if feedback	No	Audition	Yes	0.02-2
22. Radiovision	No	No	No	No	No	Yes, if feedback	No	Vision & audition	Only the audio signal	0.02-1
23. Slow-scan TV	No	No	No	No	No	Yes, if feedback	No	Vision	Yes	0.02-1
24. Broadcast live instructional TV	No	Yes	Yes	No	No	Yes, if feedback	No	Vision & audition	Yes	0.02-1
25. Closed-circuit live instructional TV	No	Yes	No	No	No	Yes, if feedback	No	Vision & audition	Yes	0.03-3
26. Broadcast tape-recorded instructional TV	No	Yes	Yes	No	No*	No	No	Vision & audition	Yes	0.01-1
27. Closed-circuit tape-recorded instructional TV	No	Yes	No	No	No*	No	No	Vision & audition	Yes	0.03-2

Table 3 (cont.)

Instructional Medium	Can user carry it around?	Can user use it individually at school or college?	Can user use it individually at home?	Can user determine when it is to be used?	Can user control rate of information flow & repeat if not understood?	Can user interact actively with input?	Is individualized "branching" possible?	Senses used	Are signals sent on electronic network?	Costs (in dollars per user hour)
28. Facsimile transmission	Yes	Yes	Possibly	Yes, during hours sender is able to transmit to user	No	No	No	Vision	Yes	2-15
29. Audio pointer	Yes	Yes	Yes	Yes	Yes	No	No	Vision & audition	No	0.05-0.25
30. Phone vision	No	Yes	Yes	Yes	Yes	Yes	Yes	Vision & audition	Yes	0.50-2
31. On-line computer aids to learning & scholarship	No	Yes	Rarely	Yes, unless too many other terminals are in use	Yes	Yes	Yes	Vision	Yes	5-100
32. Instructional computerized games and simulations	No	Yes	Rarely	Sometimes	Yes	Yes	Yes	Vision	Yes	2-25
33. Computerized programmed instruction	No	Yes	Rarely	Yes, unless too many other terminals are in use	Yes	Yes	Yes	Vision & rarely audition	Yes	2-25
34. Videotape or disc recorders	Possibly	Yes	Possibly	Yes	Yes	No	No	Vision & audition	No	0.15-2
35. Video language laboratories	No	Yes	No	Yes	Yes	Yes	No	Vision & audition	Yes	0.25-2
36. Computers which output visual words and numbers, moving and still pictures, and audio language	No	Yes	No	Yes	Yes	Yes	Yes	Vision & audition	Yes	5-100

Table 3 (cont.)

Instructional Medium	Can user carry it around?	Can user use it individually at school or college?	Can user use it individually at home?	Can user determine when it is to be used?	Can user control rate of information flow & repeat if not understood?	Can user interact actively with input?	Is individualized "branching" possible?	Senses used	Are signals sent on electronic network?	Costs (in dollars per user hour)
37. TV information storage	Yes	Yes	No	Yes	Yes	Yes	Yes	Vision & audition	Yes	2-25
38. Holographic information storage	No	Yes	Possibly	Yes	Yes	Yes	Yes	Vision	Yes	2-25
39. Instructional interactive TV, time-shared TV	No	Yes	Yes	Yes	Yes	Yes	Yes	Vision & audition	Yes	0.25-5
40. Dial-access instructional TV	No	Yes	No	Yes, unless too many other terminals are in use	Sometimes	Rarely	No	Vision & audition	Yes	0.25-5

Table 3. Characteristics and Costs of Various Instructional Media

designs are made by teachers or by students themselves using molded rubber figures and figurines mass-produced by the same process as rubber stamps used on business forms, letters, and envelopes. Trimmed and glued to wooden blocks, a typical set of such stamps includes 50 to 100 different pictures (human figures in various postures plus various geometrical shapes). They are used to provide individualized instructional materials--stories and cartoons. Illiterate people can take "notes" with them, producing a record for future reference. Microform includes microfilm, microcards, and microfiche which can be viewed with a projector or printed out on paper as full-size hard copy. Sound-on-slides are 2" x 2" slides that carry on one side an area of magnetic tape for recording. They are projected by special slide projectors which have an audio head for playing what is recorded on the magnetic tape. Audio flip is a cassette tape recorder with a flip chart.[1] Telewriting is remote control of a stylus for writing over an electronic narrow-band channel like a telephone line, audio channel, or alternating current power line. This writing can be displayed to a class by a projector, as it is being done. An audio signal accompanies it, and can be two-way. Telewritevision in addition uses the same projector and screen to show visual materials provided locally. Telelecture is a lecture by telephone coordinated with visual materials displayed locally. Radiovision is the same thing with sound by radio instead of telephone. Slow-scan television is transmission of TV still pictures over a medium of narrow-band width like radio or telephone channels. Only one picture can be transmitted every few seconds. Audio pointer

is little known. It is a medium based on an audio cassettee which has a sound track and a second signal track that controls the movement of a spot of light over a translucent sheet on which pictures or designs can appear. Thus, the light can point to various parts of the display in coordination with the sound track. "On-line computer aids to learning and scholarship" refers to such technologies as Project MAC at MIT. An individual user of Project MAC can get access, by a remote terminal on-line to a large time-sharing computer, to a wide range of programs that can help him solve mathematical, scientific, and engineering problems, routines for displaying the results of such problem solutions, tests of students' content knowledge in different fields, psychological and behavioral tests, and references or abstracts of articles relevant to many academic tasks. All of these materials are almost instantaneously available for the user to interact with in a "conversational" mode that requires little or no understanding of mathematics or computer programming. "Instructional computerized games" refers to various sorts of war games, business management games, and similar exercises in which players representing competing interests interact with a computer and so learn how to deal with competitors or opponents like those in real life. "Simulations" are models of real systems programmed in computers which enable a person interacting with them to learn how such systems act. TV information storage is use of TV tape to store symbols and still and moving pictures. Holographic information storage uses the relatively newly developed hologram, a three-dimensional picture stored on a two-dimensional plane surface, to store a large amount of information in a relatively small area. Also highly advanced, largely in the future, are

interactive and time-shared TV, which are among the novel forms of TV which Licklider has called "televistas."[2] These include specialized transmissions to individual users which he calls "narrowcasting" and techniques which permit the receiver to respond actively to television transmissions as well as employ television channels to use a variety of other instructional media. A number of other media and combinations might be listed, but Table 3 is sufficient to give a panoramic view of the alternative media available to educational systems today.

Many persons concerned with the field of education are scarcely aware that there are as many alternative forms of instructional technology, or at least they have not had direct personal experience with them. One reason for this is that the number of media has risen dramatically because of technological developments in the last decade or two. When the educators were themselves in school or college, some media did not yet exist. We see in operation prostheses to aid living systems in the activities of the entire range of their information-processing subsystems. These include input transducers--microphones, sonar, radar--which can receive signals that cannot be detected by any unaided living systems; channels and nets which can transmit information at the speed of light and for great distances; computer aids to learning, to memory, to management decision making; and output transducers like slide projectors, public address systems, radio, and television that can transmit messages rapidly, accurately, over greater distances, and to more people than can any living system.

Any educational system that is conscientiously intent upon raising the quality and lowering the costs of its functions would do well to undertake cost-benefit or cost-effectiveness analyses, studying the trade-offs among these alternative technologies, attempting to determine which will provide the greatest excellence under what circumstances, and which will be cheapest.

Any such analysis will reveal that it is not enough simply to add these technologies to procedures already in use. This will increase costs and will, in all probability, not permit optimal use of the new methods. Rather both structure and process of the system must usually be altered, often quite fundamentally. People must change their ways. Budgets must be adjusted.

A brief inspection of Table 3 indicates a number of things about the various instructional media available today. The first two listed involve only living systems and do not require any artifacts as prostheses. For this reason they are separated by a double line from the other media below them. The first two are the traditional media which have been used for generations, and the choice between them has classically faced educators--whether to use large class lectures or small discussion groups (including individual tutorial sessions).

If one looks across the columns on the chart, it is apparent that the media differ widely in their characteristics and costs. This fact makes evaluation of their cost-effectiveness in different learning situations and with different sorts of students essential.

A large body of research on learning, in general psychology and educational psychology, gives us some idea of what constitutes an optimal learning environment. One cannot say that this knowledge is yet definitive, and it clearly differs from individual to individual, since each one's genetic characteristics and past experiences result in differences in behavior, personality, and temperament. Nevertheless, we can say with some confidence that aids to learning are most useful if the student can (a) carry them around, for then they are available whenever needed; (b) use them individually rather than having to coordinate his activities with class groups or other students; (c) use the aids anywhere, both at school or college and at home; (d) determine in terms of his own needs and schedule when to use the materials; (e) control the rate of flow of information inputs and outputs in the learning process, and repeat inputs at will if they are not understood; (f) interact actively with the aids, since active learning is generally recognized as being better than passive; (g) be able to have outputs from him influence the next input coming to him. This "branching" arrangement assures that, if he knows one fact in the progression of the learning process, he is not given special training on it but goes on to the next one and so forth until he comes to a fact which he does not know or a problem which he cannot solve properly, after which he is given special training on that, his time being used for practice only on those facts or problems which he does not understand; (h) receive inputs in more than one sensory modality, since multiple sensory modalities represent multiple channels of input which reinforce

each other. Learning aids are more useful if they can be transmitted over electronic networks so that they can reach the student at any place he happens to be, coming rapidly and accurately from any other geographical location. It is also desirable for their costs to be minimal in dollars per user hour, as well as in the time they consume of the student or instructor involved.

None of the media listed in Table 3 is optimal in all these ways. Some are better than others, and some are more appropriate than others for certain situations or when certain amounts of funds are available to the educational system. These differences among the media make careful analysis of the trade-offs among them mandatory.

For instance, the first column shows that less than half of the media listed are truly portable. None of the other media, in their present form, are truly portable so far as the average student is concerned. Technical advances may make some of them much more portable in the near future.

The second column in Table 3 shows that students working alone at school or college can profit from most of the media, the exceptions being the class lectures, tutorial sessions or small group discussions, stage scenery sets, dramatizations, field trips, telewriting, telewritevision, radiovision, slow scan TV, the audio pointer, and closed-circuit lectures on public address systems. Students can use slightly more than half of the media at home. Technical improvements in a number of others could render them readily available for home study.

A major constraint upon several of the media, as the fourth column indicates, is that the student must fit his schedule and convenience to that of a group, which limits the most effective use of his time.

This is true of class lectures; small group discussions; all broadcast and closed-circuit programs; stage scenery sets; dramatizations; and field trips. Probably any form of radio or television which requires large numbers of students to use the medium simultaneously regiments them undesirably. This may be a major reason why instructional radio and television have not been more effective. The custom of herding students into classes at certain hours is so ingrained in the world's educational systems that it is hard to break. Many teachers forget or actually do not believe that usually the optimal learning situation is probably one in which each student sets his own schedule and studies independently at his own pace.

If the individual student can control the rate of information flow during learning, he is not likely to fall behind in understanding the content or be bored waiting for new concepts to come to him. Many of the media, as the fifth column of Table 3 shows, give the student this sort of control, but some do not. Students rarely exert any influence on the rate of progress of class lectures, which is one of the primary reasons why lectures are far from perfect learning situations. More often students can exert such influence in small group discussions, and in tutorial sessions they usually do. If a teaching group is very large, however, some of the students are likely to be too passive or too shy to request a change when the rate of information flow is not optimal for them. Tradition dictates that the experienced, senior person--the teacher--determines information flow rates. Broadcast and closed-circuit lectures on any media, live or recorded, have these

shortcomings as well. Exceptions are dial-access TV systems or TV or audio tape players which permit a student to stop a lecture at will, reverse it, and listen to it again. Many other media are self-pacing.

Most of the media do not permit the user to interact actively with the input. This is one of the great advantages of the small discussion group and a major point in favor of computerized programmed instruction and of on-line computer aids to learning and scholarship. Under some circumstances, dial-access audio tape recordings make such interaction possible. For instance, a language laboratory tape may present a student with a word or sentence in a foreign language and give him an opportunity to repeat the word or sentence, which is then tape-recorded and later listened to by a teacher who corrects his pronunciation. Similar procedures are possible with dial-access instructional television. Under some circumstances a student or professor can interact with automated data banks for information storage and with some of the standard audio-visual aids. Feedback circuits used with media which employ communication over distance for educational purposes can enable students to interact with a live teacher. This is possible with two-way telegraph, telephone, radio, TV, telewriting, slow scan TV, or combinations of such media, e.g., TV from teacher to student with radio or telephone responses. Also telegraph, telephone, radio, or TV responses from students can be used with telewritevision, telelecture, and radiovision. Such feedback circuits can also enable a student to interact at a distance with computerized programmed instructional materials which can be transmitted to him by audio circuits, TV, or slow scan TV.

A major potential of programmed instruction and on-line use of computers is individualized instruction. With them a student does not need to rehearse repeatedly material he already knows. He employs the time saved from avoiding unnecessary repetition, instead, in further practice on what he does not know. This can enable the student to save time, or at least allocate it better, in the learning process. Lectures and broadcasts do not usually have such a potential, although on occasion very small discussion groups or individual tutorial sessions do. The programming technique whereby each student is given practice only on what he does not know is called "branching." Such branching is less personalized, flexible, and sophisticated in the best printed programmed instruction than in the best computerized programmed instruction and on-line computer aids to learning and scholarship. Various automated storage and retrieval technologies also permit a close tailoring of the process to the needs of the individual user.

As the eighth column of Table 3 indicates, the face-to-face human situation in class lectures, tutorial sessions, and small group discussions has the distinct advantage of permitting use of both vision and audition, as well as some of the other sensory modalities on occasion. Books, journals, printed programmed instruction, closed-circuit lectures on audio systems, educational radio, fascimile transmission of documents by electronic circuits, and certain other media do not use both sensory modalities. Other media do use both, such as sound moving pictures, and in more limited ways, telelecture, radiovision, and audio pointer. So do the different forms of

television. This is one reason why television is probably superior in conveying a sense of intimate and direct human relationships to books, computer terminals, or radio.

If educational materials can be transmitted over electronic channels and networks, they can, in principle, be initiated at any geographical point and be used at any other point. This facilitates diffusion of knowledge and makes possible democracy of access to educational information. The face-to-face relationships of tutorial sessions, small group discussions, and class lectures do not have this potential, nor do many other media like documents, books, journals, printed programmed instruction, or the standard audiovisual aids. As the next-to-last column of Table 3 shows, most of the electronic media do. In the last few years educators have been presented with a challenge they never faced before: How can one best choose among the new network media most profitably and creatively use them for education?

Now we come to the question of costs. The last column of Table 3 lists only roughly estimated dollar costs in various sorts of matter-energy and information, although, of course, costs in student, teacher, administrative, and other staff time are also important. The dollar estimates include both operating funds and an appropriate portion of capital construction funds. For each of the media a wide range in costs is shown. This is because costs differ from one situation to another and because it is difficult to make even rough cost estimates with our present understanding of the media. Many variables influence the dollar cost per user hour of these different media. Among these are: the number of students using the medium at a given location and a given time; the ratio between the number

of students and the number of instructors; the amount of hardware employed in the particular system under study; the number of hours the hardware is used on the average by each student; the original costs of the hardware (which over the years have been rapidly decreasing); whether the hardware is bought in large quantities; and whether the software needs to be written for the local system or has already been prepared for another system.

A few general observations about costs can be made: (a) Large class lectures are less expensive than small group discussions. (b) Even though none of the electronic media has all the advantages of direct human contact, some of them appear to be, at least potentially, as cheap or cheaper than traditional methods of teaching by direct human contact. (c) Books, journals, and other printed materials are, in general, cheaper than most of the electronic technologies, though this is not necessarily true when the latter are used with large numbers of students. (d) Electronic technologies involving both vision and audition are more expensive than those that involve audition alone. (e) Those media which involve on-line access to computers are, in general, significantly more expensive than the other media, at least at their present stage of development. But in all probability this will not be true in a few years, for the costs of these media are decreasing rapidly. The costs of large computers, which offer major economies of scale, are declining so fast that, with thousands of students using them, the cost per student hour may be only a few cents. A minicomputer does not offer such economies of scale, but it has other advantages. A minicomputer of a capability which cost $25,000 in 1965, in 1973 costs only about $4,100. After presenting many facts of this sort, Levien has concluded:[3]

"First, on the whole, computer technology is likely to be quite adequate to support effective instructional computer use at reasonable cost....

"Second, there are certain areas in which progress is most important for instruction. Terminals and communications need to be reduced in cost and increased in capability. Time-sharing system programs capable of handling hundreds or thousands of simultaneous terminal users must be developed. Techniques for developing applications programs and disseminating them via centrally stored libraries or cassettes need to be developed. Methods for interconnecting computers in...networks must be developed and worked out in practice.

"Third, three separate trends of systems development will be pursued in parallel: decentralized, minicomputer systems; large, centralized computer systems; and computer networks."

2. Relative Promise of the Technologies

The first two modes of teaching listed in Table 3, tutorial sessions or small group discussions and class lectures, depend exclusively on local talent. In many of the less developed countries the teachers in many of the schools are untrained or only partly trained. The quality of instruction can never exceed their capabilities. All the other media have the potential of improving educational excellence by importing information and instructional procedures from experienced and perhaps outstanding teachers outside the school. This possibility of rapid improvement in quality is perhaps the greatest argument for the use of the new technologies, although the possibilities of greater

individualization of instruction and of lower costs are also potent arguments. Let us now review the arguments for and against each of the 40 sorts of technologies listed in Table 3, identifying those with major promise and those which at present seem less satisfactory.

Commenting in turn on each of the media in Table 3, we can briefly summarize their apparent present promise for education in less developed countries:

1. Tutorial sessions or small group discussions are very expensive compared with traditional classroom teaching, and to be at all effective they require trained teachers.

2. Class lectures are expensive, though less so than tutorial sessions or small group discussions. If class instruction is to be reasonably good, the teachers must be trained.

3. Lettering, writing on blackboard, charts, flash cards, flannel boards, diagrams, graphs, maps, fotonovelas, billboards, rubber stamp designs, and such media usually require trained teachers for quality instruction. Some, however, have built into them enough instruction that they can provide learning opportunities with less qualified instructors. Their costs are relatively low.

4. Stage scenery sets are of limited value in education as a whole because they are used primarily in dramatic arts. Their costs are relatively great.

5. Letters, written papers, documents, books, workbooks, comic books, tests, programmed textbooks, other printed educational materials, newspapers, journals, pamphlets, computer print-outs, Braille writings,

and punched paper tapes have been used in a wide range of educational situations with demonstrated effectiveness, but for large numbers of students they are relatively expensive to reproduce and distribute. Programmed textbooks and other similarily programmed documents have certain advantages over the other media in this category in that a student can interact actively with the inputs, giving an answer to questions and then learning from the document whether the answer was correct. Also individualized "branching" is possible. Such programmed documents share these characteristics with two other sorts of media discussed below, teaching machines and computerized programmed instruction.

6. Demonstrations are valued primarily in the scientific fields and so are specialized media.

7. Dramatizations are applicable primarily in theatrical arts, and they are costly. There is no complete substitute for them, however.

8. Exhibits are of limited applicability to a specialized range of areas, especially the physical sciences, natural history, history and anthropology, and the technologies.

9. Field trips are of limited applicability to a specialized range of areas, geology, natural studies, and various applied arts. In addition they might be quite expensive.

10. Photographs, filmstrips, film loops, and microform are fairly expensive to reproduce and often not easy to distribute. They offer no opportunity for active interaction by the student or individualized "branching." They have none of the advantages of audio signals or of motion.

11. Teaching machines are a major medium, because of their flexibility. As yet they are not sufficiently cheap to be broadly useful in less developed countries, but it is probable that, either in a noncomputerized or computerized form, teaching machines will ultimately have great impact for such mass instruction. They share with programmed textbooks, mentioned above, and computerized programmed instruction, mentioned below, certain special characteristics of all programmed instruction, such as that a student can interact actively with the inputs and that individualized "branching" is possible.

12. Silent motion pictures are expensive to reproduce and to distribute. They provide no opportunities for active interaction by the student or for individualized "branching." They also do not have the advantages of sound. They can be distributed less expensively over television networks and when so used have essentially the same advantages as video tapes.

13. Filmstrips, film loops, slides with audio tapes, sound-on-slides, and audio flip are fairly expensive to reproduce and to distribute. They offer no opportunity for active interaction by the student or individualized "branching."

14. Sound motion pictures are expensive to reproduce and to distribute. They provide no opportunities for active interaction by the student or for individualized "branching." They can be distributed less expensively over television networks, and under those circumstances they have many of the advantages of taped television.

15. Telephone network transmission costs are high for educational uses. In less developed countries telephone networks often operate poorly. In

some areas they are nonexistent. This medium does not have the advantages of video signals, but it is as yet unclear whether video signals significantly improve the learning environment.

16. Broadcast live instructional radio is a major medium. It does not permit active interaction by students or individualized "branching." It does not have the advantages of video signals, but, as noted above, it is unclear whether and to what extent video signals improve the learning environment. It is potentially inexpensive, $0.01 to $1.00 per student hour.

17. Telewriting and telewritevision are interesting new media, as yet not widely used. They are not portable, and the equipment necessary for receiving the signals is relatively expensive. Students can interact actively with the input only if there is a feedback channel for audio signals, and this means that essentially two channels in one direction and one in the other are required, a total of three telephone channels. This is expensive over long distances, and in addition, as noted, telephone networks in less developed countries are often poorly operated and at places are nonexistent. Furthermore, telewriting on the screen is often distracting to students watching the process, since the pattern builds up slowly. Of course it is also true when a teacher writes on the blackboard that the students' time is wasted while they wait for the words or pictures to be formed. Telewritevision requires local visual materials, which must be transmitted by mails or by other means that are relatively expensive. Often the signals on these media are not clear. These media employ limited bandwidths and consequently do not have the advantages of media that depict free motion. Probably they will be replaced by other media wherever greater bandwidth becomes available.

18. Audio tapes, cassette, cartridge, and record players do not give a student an opportunity to interact actively with the input and do not allow for individualized "branching." In addition they do not have the advantages of video signals. If they are used on an electronic network, they have the same advantages and disadvantages as radio.

19. Dial-access audio tapes constitute an expensive medium. The networks over which remote access to the tapes is obtained are also expensive to operate. As noted above, long distance telephone networks are not always well operated or even in existence in less developed countries. Sometimes, of course, dial-access is provided over limited networks in a single school or locality.

20. Teletype and telegraph are relatively expensive media. Networks over which the signals pass are expensive to operate and must be in existence. This is not always true in less developed countries. Also the rate of input of information is restricted to about 40 to 50 words a minute and there can be only one or very few users at a time at each terminal.

21. Closed-circuit audio lectures can take advantage of talent available in an entire school rather than a single classroom but inputs cannot originate from other locations. Only students with speakers connected to the circuit can hear the lecture--it is not broadcast to an entire community or region. This medium does not permit a student to have active interaction with the inputs and it does not permit individualized "branching," any more than classroom lectures do. Also it has the disadvantage of providing only audio signals. On the other hand, it is less expensive than single classroom lectures.

22. Radiovision is an expensive medium, requiring some form of delivery of the visual materials from a central source to the remote place where they are used. Also it provides no visual motion and there is no individualized "branching."

23. Slow-scan TV is a narrow-band medium which provides a series of still pictures, but no motion pictures. The buildup of the pictures is slow. While this is going on the attention of the student is easily distracted from the concomitant audio inputs. Often the video signal is not very good. The technology has not been thoroughly tested. There is no individualized "branching." Also it is dependent upon the existence of a telephone or alternating current network, which may not be present in a less developed country or which may carry a poor signal.

24. Broadcast live TV is a medium of major importance, the one to which most attention is now being given in less developed countries. It has certain shortcomings. No individualized "branching" is possible. If used with mass audiences it is potentially cheap in terms of the cost per student hour, but it is still more expensive than radio because the receiving sets are more costly. Maintenance and provision of the necessary electrical power may be difficult in less developed countries.

25. Closed-circuit live instructional TV has the same characteristics as broadcast live instructional TV, except that it is limited to local talent and all viewers must be connected with the network--the signal is not broadcast to an entire community or region.

26. Broadcast tape-recorded instructional TV has the same characteristics as broadcast live instructional TV, except that a student cannot interact actively with the input, as he can with live broadcast TV if an audio feedback channel is provided.

27. Closed-circuit tape-recorded instructional TV is just like closed-circuit live instructional TV except that a student cannot interact actively with the input.

28. Facsimile transmission is an expensive medium. It requires existence of a good telephone network, which may not be available in less developed countries. Moreover, the specialized accomplishment of this medium is to shorten to minutes the delivery time over distance of printed or graphic documents. Such speed of delivery is not vital to primary or secondary educational systems, although it possibly may be for higher educational activities in which the demand for scholarly materials is not predictable. It could be especially valuable in nations that do not have an adequate network of scholarly libraries.

29. Audio pointer is a little-known and as yet relatively untried method with many of the characteristics of teaching machines. It does not have the advantages of visual motion and a student cannot interact actively with the inputs. It is fairly expensive.

30. Phonevision requires a wide-band telephone network, a coaxial cable network, or similar wide-band channels which are ordinarily not available in less developed countries. Also it is expensive.

31. On-line computer aids to learning and scholarship are too expensive at present for use by less developed countries. They are far from being perfected, and are of value primarily to higher education.

32. Instructional computerized games and simulations are too expensive at present for use by less developed countries. They are far from being perfected, and are of value primarily to higher education.

33. Computerized programmed instruction is a major medium because it constitutes an extremely flexible learning environment. It shares with other forms of programmed instruction, mentioned above, programmed textbooks, and teaching machines, the capability of enabling a student to interact actively with inputs and of permitting individualized "branching." It is still too expensive for less developed countries, but its costs are going down rapidly and attempts are beginning to be made to employ it in less developed countries. As noted above, the costs are likely to fall within the next few years to such a point that serious consideration of this medium is justified. This will also be true of teaching machines which have similar characteristics although not the flexibility of computer-aided or computer-managed instruction.

34. Video tape or disc players constitute a major medium with the same advantages and disadvantages as TV except that a student cannot interact actively with the inputs. Distribution costs of the video cassettes or discs are high and maintenance may constitute a serious problem. There are certain special advantages of this medium, including the fact that scheduling of the use of programs can be controlled locally. Also the rate of input can be controlled by an individual student and he can reverse the program and play it over again. At present this new medium is quite expensive, from $0.25 to $2.00 per student hour, but this can go down quickly, especially when efficient disc recorders which are similar to phonographs but which play video programs on ordinary TV sets come on the market.

35. Video language laboratories. These are largely untried as yet, and are certainly too expensive at present for less developed countries. It is uncertain whether concomitant video and audio signals are better than audio signals alone in language learning.

36. Computers which output visual words and numbers, moving and still pictures, and audio language are still experimental and are too expensive for less developed countries.

37. TV information storage is still experimental and too expensive for less developed countries.

38. Holographic information storage is still experimental and too expensive for less developed countries.

39. Instructional interactive TV or time-shared TV are still in the experimental stage and too expensive for less developed countries.

40. Dial-access instructional TV is still in the experimental stage and too expensive for less developed countries.

The list of instructional technology alternatives available today is long and their strengths, weaknesses, and costs vary over a wide range. To select among them in a given specific situation is not easy. In the subsequent chapters we shall analyze strategies for making such choices.

CHAPTER III

Notes and References

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CHAPTER IV

COSTS--THE MEASURES OF INPUTS TO EDUCATIONAL SYSTEMS

1. Introduction

Throughout the world there is a growing awareness of the vastness of the task which faces the various national educational systems. For several reasons educators are referring to the situation as the "crisis in education." The principal reason given is that the resources available are inadequate to provide a satisfactory education by traditional methods to everyone who wants or needs it, to all the people for whom such an education may well mean the difference between mere existence and a satisfying life.

Because the essential task of education is a particular sort of information processing, the use of various information processing media or instructional technologies is being investigated in many countries. This is one approach to improving educational cost-effectiveness, obtaining better and cheaper education in nations where low gross national products doom the educational systems to inadequate budgets. This approach has real potential, yet instructional technology, with few if any exceptions, is being used in a piecemeal fashion. This nullifies one clear advantage it has for reducing costs, that of being able to increase the student-teacher ratio. The importance of this has been pointed out by Tickton, who asserted before the President's Commission on School Finance that

the only way to reduce educational unit costs substantially is to increase the student-teacher ratio dramatically.[1]

In this chapter we shall consider the problems of measuring costs in educational systems of various sorts, including the costs of instructional technology employed as prostheses to replace or alter functions carried out by human beings in traditional educational organizations. On pages 50 and 51 above we defined the costs of living systems: "All adjustment processes have their costs, in energy of nonliving or living systems, in material resources, in information (including in social systems a special form of information, money, often conveyed on a metal or paper marker), or in time required for an action. Any of these may be scarce. (Time is a scarcity for mortal living systems.) Any of these is valued if it is essential for reducing strains. The costs of adjustment processes differ from one to another and from time to time. They may be immediate or delayed, short-term or long-term."

Costs are measures of inputs to systems or resources used by them. The effectiveness of systems can also be determined by measures of their outputs. To be precise about measuring the inputs and outputs of systems, the system must first be clearly defined and its boundary subsystem be accurately identified so that one can be sure exactly what is input and output to it over the time from the original planning or reproducing of the system up to the present.

For purposes of conceptual rigor it is important to distinguish clearly between the various classes of resources, particularly between various sorts of matter-energy inputs and of information inputs, and

between living and nonliving inputs. It is also important to recognize that there are mixed inputs, for example, human beings (which we classify as a particular sort of matter-energy) who enter a system but who bring information with them, or money, which although it is borne on a matter-energy marker actually fundamentally is a particular sort of information, different, for instance, from that conveyed on the matter-energy marker of a book or magazine.

A conceptual confusion arises when no clear distinction is made among the various sorts of costs or resource inputs into a system. Even systems theorists frequently neglect to make such distinctions, with the result that very different sorts of resources are grouped together as if they were similar things. For example, one systems theorist recently has listed the following as inputs to living systems without making any distinction among them: Funds, manpower, time, facilities, materials, education, and natural resources such as air, water, and land.[2]

In calculating the costs of operating a living system (the resources or inputs necessary for it to carry out its processes) one must not only distinguish among the various sorts of inputs required but also determine at what rate each sort is required by every subsystem or component, i.e., program, of the system. To do this it is first necessary to agree upon a taxonomy or listing of all the subsystems and components or programs. We have listed the subsystems of living systems above (see pages 35, 38, 39, and 40 and also pages 65 to 75). For instance, the costs of each subsystem of a school, a school system, a college, or a university are stated in the following examples:

Reproducer. Costs of reproducing. Example: A $4,000,000 bond issue was authorized for constructing the new building.

Boundary. Costs of matter-energy processing at the boundary. Example: The new electronic equipment, which counted the number of students entering the school each day, cost $1,300. Cost of information processing at the boundary. Example: The mail room staff of four men devoted the first hour of every working day to sorting the mail for the entire university, a total of four man hours.

Ingestor. Costs of ingesting. Example: The new purchasing officer of the school system commanded a salary $6,000 greater than his predecessor's and insisted upon two assistants and two secretaries.

Distributor. Costs of distributing. Example: The new automatic shelving device for the university library decreased the number of employees needed by six and so saved $3,000 a month in wages, but the electric power to run the equipment cost $120 a month.

Converter. Costs of converting. Example: The butcher in the school cafeteria cut fat and bone from the meat before it was cooked, so that it weighed only 87 percent of what it did when it was purchased; this increased the actual cost of the cooked meat from $1.00 to $1.15 per pound.

Producer. Costs of producing. Example: Raw materials used in the school's workshop cost an average of more than $800 a month.

Matter-energy storage. Costs of storing. Example: The school system constructed a new building for storing school books at a cost of $50,000. Costs of retrieval. Example: The university paid

union scale to the attendants who brought the cars to the entrance of the faculty parking lot.

Extruder. Costs of extruding. Example: Two maintenance men worked full time removing garbage and trash from the college.

Motor. Costs of moving. Example: The university spent $125,000 a year to operate its motor pool.

Supporter. Costs of supporting. Example: The new two-room school building cost the province $1,700.

Input transducer. Costs of input transducing. Example: The accountant calculated that the employees of the school system spent more than four man years annually listening to comments about school operations from parents and others in the community.

Internal transducer. Costs of internal transducing. Example: The survey conducted among the teachers to learn about their attitudes toward their work cost the school system $3,200.

Channel and net. Costs of channel and net processing. Example: A coordinator was paid $16,000 annually to expedite reports and correct distortions in the flow of management information in the university.

Decoder. Costs of decoding. Example: A consultant was paid $100 a day by the school to explain advances in the field of instructional technology to the teachers.

Associator. Costs of associating. Example: Five years were lost and more than one generation of American Indian students refused to come to the school before the principal realized that subtle antagonisms shown by the teachers of Spanish ancestry kept the Indian children away.

Memory. Costs of reading into memory. Example: Each clerk in the registrar's office was paid about $2,000 annually for keeping student records. Cost of retrieval from memory. Example: The computer printouts of the class lists cost the college $300.

Decider. Costs of deciding. Example: The faculty committee worked with the principal of the school for 16 months before they finally agreed to use closed-circuit television.

Encoder. Costs of encoding. Example: The new writer in the public relations department of the school system received $12,000 annually, raising the total annual budget of the department to $87,000.

Output transducer. Costs of output transducing. Example: The college paid $107,000 a year to support the 7 engineers required to operate its educational television station.

For any educational system program budgeting is fundamentally breaking down total costs into the costs for each subsystem and component or program, like the above examples. The totality of the costs or inputs required for the total system is the sum of all of these individual items minus those that are produced inside the system. While many costs mentioned in the examples were expressed in monetary terms, other costs were expressed in terms of various kinds of matter-energy such as buildings, equipment, personnel, and personnel effort; various sorts of nonmonetary information; and temporal units measuring the passage of a period of time with all the consequences.

2. Cost Analysis

2.1 Basic concepts of cost analysis. The process of cost analysis begins with the determination of all the past and present different sorts of costs of various subsystems and components or programs of the system. It goes on to an estimation of all such future costs under various alternative circumstances, given specified constraints and objectives. Costing must be done in terms not only of the money required but also of all the other sorts of resources which must be input to the system if it is to operate. These costs are determined individually and also totaled for the whole system. The process, when properly carried out, forces planners and decision-makers to state the objectives (or purposes and goals) of the system clearly. Once these are stipulated, alternative ways to achieve them can be designed and the relative costs of these alternatives can be estimated. Cost information of itself does not lead inevitably to a decision but it constitutes a prime essential for a rational choice among alternative systems.

The following are several basic concepts of cost analysis:

2.1.1 Fixed Costs. These are costs that are insensitive and very large limits do not vary with change in the number of units of production or output of the system, whether the output be products or services. Examples are the rent for facilities or a piece of equipment used to produce the output, or regular monthly debt payments on such facilities. Such costs are the same no matter whether there is one unit

of output per time interval or many units of output. On the other hand, as the units of output per time interval increase the fixed costs per unit decrease.

2.1.2 Variable costs. These costs vary as a function of the number of products output by the system, the number of individuals served by it or the number of services provided. They may or may not vary proportionately. As the number of output units per time interval increases, costs per unit decrease and the efficiency of the system increases.

2.1.3 Total costs. The total costs for a system over a given period of time are the sum of the fixed costs plus the variable costs per unit of output times the number of units of output. That is T (N) = X plus NY, where T is the total costs, N is the number of output units, X is the fixed costs, and Y is the variable costs per unit of output.

As Schramm, Coombs, Kahnert, and Lyle note, in agreement with my view expressed above (see page 50), total costs include more than monetary inputs, although monetary value can be put on some of the other sorts of inputs:[3]

"Even if budgetary accounts are in good order, it is evident that the full costs always cover more than actual budget expenditures. In investment costs, for example, existing buildings, available technical facilities, and furniture and transport do not lead to budgetary expenditures at the start of the project, but have to be taken into account when estimating the total demand made on the country's resources. In current costs, such items such as depreciation of buildings and other facilities,

voluntary work, free air time, and a notional interest on the capital tied up in the project, must be included. Usually, these are not included in the accounts kept by the projects, because they do not yet represent actual cash expenditures. Since ultimately they would probably have to be faced by the budget anyway, we have had to estimate such costs, and figures of this kind are often rough." They note also that various kinds of financing exist in many projects and must be taken into consideration. Funds may come both from local sources and from foreign contributors. Also often costs are shared between two or more organizations and these must be appropriately budgeted.

Commonly economists hold that total costs can be stated in money because in most economies at a given time a price can be put on any resource. This is not wholly satsifactory from the point of view of a total system analysis, however. The various sorts of matter-energy and information inputs required for a large-scale social system are incommensurable. Land, buildings, equipment, water, light, and electric energy are quite different sorts of nonliving matter-energy. Plants, animals, and human beings are other sorts of matter-energy inputs--living as opposed to the other sorts, which are nonliving. In addition a wide range of information inputs is needed for the operation of any human system. Money is only one specific sort of information input. Also the system must endure over a given period of time, and time resources must be accounted for along a temporal axis, e.g., by a PERT analysis or some other similar process. All of these different sorts of inputs can be given monetary values, but that does not make them commensurable.

In a particular practical situation, also, often all the needed inputs could not be obtained when they were wanted even if all the money required to pay for them was available. In the development and operation of any particular system at a specific place, some inputs can be obtained more easily and quickly than others at a given time. Some may be scarce or entirely unavailable. This is an important logistical reality. Thus there are aspects of inputs which cannot be expressed in monetary terms.

2.1.4 Average or unit cost. The average cost is equal to the total cost divided by the number of units of output. That is, if A(N) is the average cost, then A(N) = T(N)/N. It is the cost per unit of output, often called unit cost. It varies with N whenever there are fixed costs: A(N) = X/N + Y, where X is fixed costs and Y is variable costs.

2.1.5 Marginal costs. Jamison denotes marginal costs by the symbol M(N) and defines them as follows:[4]

"M(N) specifies for any given level of output what the incremental cost would be of increasing the output level by one; more explicitly, M(N) = DT(N)/DN. In our example, M(N) = Y which is independent of N; however, if T(N) were nonlinear to N -- as would often be the case--the marginal cost would vary with the level of output. For many decisions, the appropriate cost concept to use is marginal cost because decisions often involve expansion or contraction of a program rather than establishing a new one altogether."

2.1.6 Capital costs. Capital costs are costs incurred to acquire an input that will serve the system over an extended period of time (usually years or decades), such as land, a building, furniture, equipment, or certain forms of hardware.

2.1.7 Recurrent costs. These are costs of services and supplies that can be used up relatively quickly, ordinarily within a single accounting year. The distinction between capital costs and recurrent costs is often arbitrary.

2.1.8 Nonrecurrent start-up costs. The process of creating or reproducing a new system involves special start-up costs. These are one-time costs, even though they may continue over more than one year. They include costs of planning, recruiting, bringing on duty, and training the first personnel; obtaining land, buildings, equipment, and other needed facilities; and setting up regulations and establishing the procedures by which the system will operate.

2.1.9 Opportunity costs. This phrase refers to what the decision-maker could have obtained if he had undertaken one or more alternative activities that had to be given up in order to implement the system activity which was selected. It represents the potential payoff from possible alternate system activities. Some economists, such as Marshall, distinguish "real costs," the effort and sacrifice needed to produce certain goods or services, from the payments made to owners of the factors of production. In other words, the real costs correspond to the opportunity costs. The monetary cost to the consumer of the goods or services is deemed to represent an equivalent to the real cost to the seller. In a chain of economic transactors, starting from the first owner or producer and ending with the final consumer, the "laws of economic behavior" ordinarily insure that the cost to any given transactor is always equal to or higher than the cost to the previous transactor and equal to or less than the cost to the

next transactor. Thus, for example, the retail price of food to the final consumer is higher than its cost to the retailer (the wholesale price), which is higher than its cost to the wholesaler, which is higher than its cost to the producer.

2.1.10 Short- and long-run costs. There is a time factor to all budgets, whether they are in monetary units or other measures of inputs or resources. For any system certain inputs may be readily available but others may be delayed for months or years. Therefore certain costs are short-run and must be met immediately while others are long-run. In planning for a system over a period of years, it is important to calculate when both short- and long-run costs must be met. There are also other economic factors which vary with time that must be taken into consideration in planning, such as interest accumulation, changes in interest rates, and inflationary increases of costs.

2.2. Educational cost analyses. Educational costs are measures of the inputs or resources required by an educational system which produces certain outputs. It is not easy to specify precisely what all these inputs are. Also it is hard to decide what are the best units to use for measuring costs. Is it best to calculate costs per pupil in average daily attendance? Or per graduate? Or per unit of measured achievement gain? Should the cost be calculated for the average of all students in the system? Or determined as what additional is required to teach one more student? There is, of course, no one "correct" way to assign costs, though there are certainly some incorrect ones. The economic analyst working with the educational planner should analyze costs in the ways that are most

illuminating for the particular decisions to be made. In deciding among alternative instructional technologies, the appropriate measure might be cost per unit of achievement gain; in deciding among alternative educational strategies, it might be cost per graduate with a specified set of skills.[5]

Cost analysis has become a vital tool to educational administrators and planners. It can aid in testing the economic feasibility of educational plans, improving the allocation of available educational resources, weighing the comparative advantages of alternative ways to pursue the same objectives, projecting the short- and long-run costs of a project, estimating the introductory and continuing expenses of an educational innovation, searching for ways to improve efficiency and productivity, or predicting the economic feasibility of educational policy decisions.

The educational sector (or associator subsystem) of society produces services which aid the learning of its citizens. The same concepts which apply to other sectors of activity theoretically apply to it. Anyone involved in the costing of education, however, encounters three problems inherent in its very nature: What is the product of education? Who are the economic transactors concerned with education? And what does it mean that education has the character of a public service?

(a) The products of education. One product of educational systems is the preservation and enlargement of the body of human knowledge. Another is the creation, development, and enhancement of the quality of life of a civilization. Another is the expansion and improvement of human resources.

For simplicity, in dealing with primary and secondary education, we shall limit ourselves to the view that production of education consists of either transmitting or insuring the assimilation of a body of knowledge, or certain attitudes, feelings, or ways of behavior. These definitions simplify the ideas of education to such an extent that from one point of view they may amount to a misrepresentation. Some educators for example, might challenge them and contend that education is not transmitted by the teacher, who only creates or should create the necessary conditions to enable the pupils to become educated.

(b) The economic transactors concerned with education. The producers are the teacher and his assistants, the educational establishment, the public authority administering education, a private agency in the case of private education, families who rear children at home, or any other nonformal teaching institution. The consumers are the students, as well as families that in a sense "buy" education for their children. One can distinguish the costs to the producers in terms of their expenditures from the costs to the consumers in taxes and fees paid, costs of books and study aids, transportation costs, and so forth. Opportunity costs may also be included, e.g., the possible other uses of public facilities or funds or manpower for functions besides education and the income foregone by families because they send their children to school, instead of sending them out to work. Of course this is not a real cost to families if jobs for the children do not exist.

(c) Education as a public service. From the point of view of a particular producer (one educational organization) and a single consumer (a single student or family) there is no very close relationship between the cost to the producer and the cost to the consumer.

In the first place, the public educational organization does not usually bear the whole of its operating costs, since its budget is usually funded by central state or national authorities. Secondly, under a free public educational system, the direct cost to the consumer is little or nothing and the indirect cost, i.e., taxation, depends not upon whether the family is a consumer of education but on other factors such as the amount of the family income or the amount of property it owns or rents. It is, therefore, reasonable in costing public education to treat all consumers as a whole and also to consider the entire educational establishment as a single economic transactor. At the level of the society costs of the producers are roughly equal to the costs paid by the consumers (neglecting any contributions from business or foreign aid). (This is obviously not true of the opportunity costs which for the consumers are virtually independent of the opportunity costs for the producers.) For all these reasons, then, the entire state or national community--whichever is fiscally autonomous--must be viewed as a single economic entity in the costing of public education.

2.2.1 Fixed costs. In educational systems these include the cost of land, buildings, furniture, equipment, instructional hardware, broadcasting studios, national transmission lines, and so forth. The cost of

each of these facilities is the same whether they are used 24 hours a day or 8 hours a day. Similarly the cost of studios and transmission lines are the same whether they are used to full capacity or only partial capacity. The same is true of all instructional hardware.

2.2.2 Variable costs. This include all operating costs of educational systems: costs for retraining teachers to use new teaching methods; for producing instructional software, and related materials, like workbooks and syllabuses; for operating broadcast studios, computers, communications lines, and other instructional technologies; for equipment maintenance; and for research, testing, and evaluation.[6]

2.2.3 Total costs. We have noted above (see pages 144 and 145) that total costs include more sorts of inputs to the system than money. Schramm, Coombs, Kahnert, and Lyle also note other aspects of educational total costs:[7]

"Another difference between budgetary costs and total costs may arise from differences in financing methods. In a number of projects, both in investments and in current costs an appreciable part of the total has been financed by various foreign-aid donors. This may considerably reduce the cash expenditures the project's promoters will have to budget for, although it is likely that ultimately these costs too will have to be taken over by the national budget. Where good accounts were kept by donor agencies and where this seemed reasonable, the total costs arising for them were included in our calculations, but in some instances we preferred to make estimates, for example in Colombia, where the foreign volunteer assistance was assessed as if Colombian salaries were being paid for the jobs.

"Another problem in gathering facts on costs is how to allocate joint costs. For example, when a project uses existing transmission facilities partly for educational purposes, when an educational production unit shares some space in an existing building, when an existing transport network is asked also to serve the new educational project, when a broadcasting unit performs tasks outside the project, when expatriate personnel hired for programme production contribute a training effect merely by working with local programmers and producers--in situations like these some formula must be found for allocating costs among two or more services, and such a formula introduces elements of uncertainties."

They go on to say:[8]

"Another difficulty in comparing current costs of projects internationally is the reliance or nonreliance of varying amounts of foreign technical assistance. Salary scales for expatriate help usually being considerably above scales for local staff, this may distort comparisons of unadjusted data. All of these factors tend to distort international comparisons....The nature of the cost data is therefore often very different. One country pays for monitors for its classroom; another pays qualified teachers. The Telescuola secondary-school programme includes in its cost estimates the salaries of teachers who supervise study groups as well as an allocation for the buildings that have to be used by the study groups; the Chicago Junior College programme, on the one hand, broadcasts to individuals sitting at home, and therefore there is no cost allocation for

a supervising teacher or for a group meeting-place. The nature of the project thus enforces a difference in cost structure."

Not only do these factors alter manpower costs but also there are differences in productivity or economies of scale in manpower utilization. As the above authors note:[9]

"Comparing the input of professional manpower in these television projects with the output of new programmes from the projects, we noticed that, in general, the larger the project the more hours of new programming it is likely to produce per man-month of professional staff."

We have said above that costs of educational systems cannot be reduced to only monetary units. The economic approach of cost-benefit analysis, however, attempts to do this. (Occasionally workers who use this approach suggest that nonmonetary units might be used in it, but this is rarely if ever done.) Such an approach has been described by Woodhall, and by Goffman and his associates.[10] This technique developed chiefly by economists, views education as an investment by the individual student and his family and by the nation, which yields economic benefits to them and contributes to their future wealth by increasing the student's productive capacity. Educational inputs and outputs, costs and benefits, are both measured in the same monetary units. Various forms of economic calculations can be employed to determine which is the optimal educational programm in terms of cost-benefits. For instance, Hirsch and Marcus have used such calculations in an analysis of desirability of universal junior

college education in the United States.[11] This "econocentric" analytic approach seems too simplistic, since both the inputs to and the outputs from educational systems are of several sorts. As Alkin, as well as Carpenter and Hoggart, point out, all aspects of them cannot be measured in monetary units.[12]

One cost-benefit approach outlined by Blaug takes into consideration, in addition to finances, a less developed country's current, and forecasted future, manpower needs.[13] Recognizing that a nation's educational system and labor market have reciprocal impact, he describes how cost-benefit analyses can be made in terms of how well the educational system meets the nation's needs for trained manpower.

As an improvement over cost-benefit analyses, Alkin proposes a model for cost-effectiveness summative evaluation of educational systems. It includes:[14] "'student inputs'--the characteristics of students entering the system; 'educational inputs'--cognitive and noncognitive changes that occurr in students after exposure to an instructional program; 'financial inputs'--financial resources available to carry on the program; 'external systems'--the social, political, legal, and economic structure of society; and, lastly, 'manipulable characteristics'--those aspects of the program which are resource-consuming and which are administratively manipulatable."

Total costs can be calculated for a single educational organization or program, a state or regional system, or a national system. When it is

done for a state, regional, or national program, the costs of the educational sector can be compared over time with the gross state product, gross regional product, or gross national product.

The value of this approach is that it indicates the comparative importance of education in the state, regional, or national economy, and opens the way for studies of financing and facilities comparisons among state, regional, or national systems as to cost effectiveness.

Once the total monetary costs of an educational program are determined, how should cost analysis proceed?

One way to study the time trend of educational expenditures is to construct a time series. In this way the general direction of change over the years is revealed. Table 4 shows an example. Column two shows that the annual budgetary growth was about 20 percent at the beginning of the period, and then fluctuated around 10 percent, with a low of 5.7 percent between 1958 and 1959, and a high of 15.5 percent between 1952 and 1953. Over the whole period, the growth of the educational budget was considerable, since the absolute value of the 1962 expenditure was more than four times the 1950 figure. It is true that the 315 percent growth in the budget does not represent a comparable growth in volume because of the rise in prices. This is confirmed in the last two columns in the table. At constant prices, the growth rate fluctuated around 5 percent and the interpretation of the table is radically changed. Over the period 1950-1962 the increase in the financial flow at constant prices was only 83 percent--still a healthy growth for 12 years. This example demonstrates the need to express the total cost of education at constant prices, if accurate understanding of changes over time is desired.

	At Present Prices	Index Previous Year Equals 100	At Constant Prices 1954	Index Previous Year Equals 104
1950	2473.2	—	3572.4	—
1951	2994.2	121.0	3767.2	105.4
1952	3519.3	117.5	4035.0	107.1
1953	4069.6	115.5	4283.2	106.1
1954	4466.9	109.8	4466.9	104.2
1955	4931.4	110.0	4668.1	104.5
1956	5613.4	113.8	4922.0	105.4
1957	6094.4	108.5	5040.7	102.4
1958	6794.7	111.5	5259.5	104.3
1959	7182.9	105.7	5519.7	104.9
1960	6244.0	—	4462.3	—
1961	9165.5	—	6095.3	—
1962	10263.8	112.0	6539.4	107.2
1962-50	—	415.0	—	183.0

Table 4. The Trend of Total Educational Expenditure in the Federal Republic of Germany, 1950-1962 (in Millions of Deutschemarks)

(From A. Palm. Die Kaufkraft der Bildeuagrausgeben.)

Such an analysis of educational budgets over time tells nothing about the relative magnitude of the educational effort, since that varies with, among other things, the population of the state, region, or country. It is therefore necessary to develop indicators so that costs of the different jurisdictions can be expressed in terms of them. The magnitude of theedcuational effort is generally compared to the gross state, regional, or national product, as the case may be. Part of this production, the magnitude of which various according to the jurisdiction's level of development, is paid for by monetary transactions. In some countries in which there is much barter as well as monetary transactions, the fraction of nonmonetized production is so large that analysts are forced to distinguish between total gross domestic product and monetized gross domestic product. For example, the breakdown of the gross domestic product between the monetized and the nonmonetized parts in 1961 in three African nations was as follows:

	MONETIZED	NON-MONETIZED
Tongo	6,180	21,520
Central African Republican	12,275	13,720 13,720
Gabon	24,400	8,145

Table 5. Gross Domestic Product (in Thousands of Millions of Francs) in 1961.

(From A. Palm. Die Kaufkraft der Bildeuagrausgeben.)

When the nonmonetized sector of the economy is so large, some economists think it more significant to express educational expenditures as a percentage of monetized gross domestic product rather than as a percentage of the total gross domestic product. The statement that such a fraction of total gross domestic proudct has been devoted to education underestimates the financial burden of education on the country, since the nation's educational effort is concentrated in the modern sector of its economy. For example, in Togo in 1961, while 34.5 percent of total gross domestic product was devoted to education, the real effort was, in fact, four times as great. This is because, out of a gross domestic product of nearly 28,000,000 francs, only 6,200,000 million francs from the monetized sector really contributed to educational financing.

Some economists point out that the distinction between monetized and nonmonetized gross domestic proudct is not easy to make. The segregation of the subsistence sector and the modern sector of the economy is not absolute in any area. The educational effort does not really concern only the modern sector, they contend, and the impact of educational development on a subsistence economy is significant. It is, therefore, a distortion to disregard the whole activity of the traditional sector and relate the costs of education to the monetized gross product alone.

The above survey is enough to show that the choice of cost indicators is far from simple or agreed upon among economists. The important thing is that, in any analysis of educational finance, particularly an inter-jurisdictional one, the indicators chosen should be clearly specified and the conclusion should be carefully limited out of consideration of the constraints upon whatever indicator is used. By way of illustration,

Table 6 shows a comparison of the educational effort as a percentage of total gross domestic product and of monetized gross domestic product and of monetized gross domestic product in six African countries in 1964.

In developing countries, the public sector generally plays a paramount part in financing education. Furthermore, since the wealth of private sources of finance is often not publically known, educational economists often have no alternative but to calculate educational budgets in terms of known public resources only.

The most usual procedure, then, is to calculate public educational expenditures, as a percentage of total public expenditures.

It is instructive to compare the proportions of total expenditures that go to education in several countries: The Philipines devotes more than 30 percent of its national budget to education. In Cameroon, however, educational expenditures in the consolidated national budget amounted to only 15.7 percent in 1963-64. In Thailand and the Ivory Coast, in 1964, the current budget of each of the Ministries of Education was about 16 percent of the national budget, but whereas in Thailand the university budgets were not included in the ministry's budget, in the Ivory Coast part of the cost of the University of Abijan was. In the Ivory Coast, moreover, if educational expenditures borne on the budgets of other ministries were included, the total educational budget would be 22.8 percent of the national budget. These examples show the difficulties of comparing national budgets.

Table 7 shows the trend between 1957 and 1964 of the proportion of the federal budget of Argentina that was devoted to education, distinguishing expenditures on public education and grants to private education.

Country	Total Gross Domestic Product	Monetized Gross Domestic Product
Zaire	8.8	12.5
Congo	4.5	7.3
Ivory Coast	7.0	14.0
Madagascar	2.2	10.0
Niger	---	--
Senegal	6.3	11.0

Table 6. Total Educational Expenditures as Percentage of Gross Domestic Product.

(From A. Palm. Die Kaufkraft der Bileuagrausgeben.)

YEAR	Public Education Percentage	Grants to Private Education Percentage	Total Percentage
1957	12.2	0.5	12.7
1958	13.7	0.7	14.4
1959	13.3	1.1	14.4
1960	11.5	1.0	12.5
1961	12.5	1.0	13.5
1962	15.8	1.6	17.4
1963	16.1	1.7	17.8
1964	17.9	1.8	19.7

Table 7. Percentage of Total Federal Budget Devoted to Education in Argentina, 1957-1964.

(From Anon: OCED Education, Human Resources and Development in Argentina. Paris, 1967, 187.)

2.2.4 Average or unit cost. How does one choose a unit for costing an educational program?[15] The data can be accumulated by either the number of teachers, the number of pupils, or perhaps the number of schools. But there are a number of major problems which the administrator or planner has to think about carefully before he selects his unit.

Do costs vary with the number of pupils? To some extent they do. If the ratio of teachers to pupils is fixed by regulation, then obviously if the number of pupils increases, so must the number of teachers. If the school administration pays for the books used by the pupils and each pupil has a given number of books, then obviously expenditures on books will also rise with the number of pupils. But many educational costs are not associated with the number of pupils. They are associated rather with the number of teachers. If the number of teachers increases, then the major part of educational outlay, which is teachers' salaries and fringe benefits, will also increase. Thus, it may well be that the best unit for costing is the number of teachers and their salaries.

No one unit, however, is suitable for all purposes. For costs other than teachers' salaries, the best unit may well be the number of square feet of building space, because the costs of heating, cleaning, and interest charges are associated more with the number and size of educational buildings than with the number of pupils or of teachers. Of course, there is a link between the number of pupils, the number of teachers, and the number of buildings. In a fairly steady situation where things are not altering much, a composite unit including all three could be adopted. But most educational planners do not find themselves in steady situations.

We can distinguish two ways of quantifying the production of education for purposes of costing: (a) by reference to promotions from one grade to another or other academic achievements; and (b) reference to the amount of student time spent in school or amount of attendance. We shall now consider the advantages and disadvantages of these different forms of unit costs:

Cost per graduate. The average cost per graduate, i.e., for successful candidates in their terminal examination at each level of education. This is arrived at by taking a national cohort of pupils or students, assessing a total cost of educating them, until they have all finished some course of instruction, and calculating the total number of graduates in the cohort. The average cost per graduate is the ratio of the total cost to the number of graduates. Data for such calculations cannot always be obtained since individual records are virtually required to be able to follow a cohort through time, together with cost statistics for each subgroup of the cohort and for each level of education. In practice, therefore, a much simpler method is followed. After estimating the average cost per student and determining the actual enrollment and number of graduates, one calculates the total cost of education and consequently the average cost per graduate. It is in this way that Table 8 is compiled.

As the table shows, despite the lack of precision of the estimates, the cost per graduate gives some useful indications of the efficiency of educational systems. Comparison of the figures in the column showing

Level	Annual Cost of Education	Length of Cycle	Theoretical Cost Per Graduate	Real Cost Per Graduate
Primary	51	6	306	800
Secondary General	104	5	520	2970
Secondary Vocation and Technical	217	5	1085	4285
University	391	5	1955	9739

Table 8. Average Cost Per Graduate in A Central American Country in 1964 (in American Dollars).

the theoretical cost and the real cost indicates how much wastage there is in students who dropout or repeat courses.

Cost by level of education obtained. Assignment of the whole financial burden to graduates alone substantially increases the cost per graduate, since it disregards all other pupils who quit the educational system after attaining a certain level. In order to take these others, into consideration, figures on costs of educating students who quit the systems after completing one or more years of study can be included. This sort of cost unit takes account of the well-established fact that those who quit the system before graduating have nevertheless acquired appreciable education, which is recognized by many prospective employers.

Unit cost per pupil. Currently this is the most used unit. Several cases discussed in this report and the appendices use it or some derivative of it. Usually recurrent costs per student rather than total costs per student are calculated since the relationship between capital expenditures in any given year and the number of students enrolled in that year has little significance.

Cost per average daily attendance. In most countries, the number of student enrollment differs greatly from the actual attendance. Therefore in their statistics total recurrent costs are divided by the average number of students attending each day, i.e., the average daily attendance.

Capital cost per student place. For capital expenditure it is often useful to calculate the cost per student place, by relating the total costs of construction and initial equipment to the number of student places provided. This cost is helpful in making construction projections.

Average cost per class. Some economists prefer average cost per class as a unit rather than unit cost for pupil because of the greater stability of the class as a unit and the ease with which this unit can be used in projections. (It remains even though some students in it drop out.) It should, however, be pointed out that this formula means that the definition of a class must be standardized in any one country and between countries for the purpose of international comparison, although the size of classes varies between countries and in the same country at different levels of education. It also may vary greatly with different instructional technologies. Indeed with some media there are no classes.

Average recurrent cost per teacher. This unit is mainly of interest to costing researchers because of its sensitivity to the major variable in educational cost and teachers' salaries. This unit obviously cannot be used without caution, especially in secondary and higher education. Since the number of students per teacher varies so much, it is hard to use this unit for many important comparisons, either over time or among schools, regions, or nations.

Jamison emphasizes the importance of using as a measure in education unit costs over a specific period of time, since they change from time to time (see Appendix A, pages A-IV-11 to A-IV-16).

2.2.5 Marginal costs. In making projections of costs with different sizes of student population, this sort of unit can be useful in planning educational and communication systems.

2.2.6 Capital costs. In educational systems these are fixed costs of school buildings, other facilities, equipment, furniture, hardware, and electrification. For various educational systems using instructional technology, these can vary from a few thousand dollars to millions.[16]

2.2.7 Recurrent costs. These are the operating costs of educational systems. Various types of cost units dealing with them have been mentioned above. Like capital costs they vary widely from one system to another and from time to time.[17]

2.2.8 Nonrecurrent start-up costs. Speagle calculated these costs for the educational reform and instruction in El Salvador and found that between 1966 and 1973 they totaled 10 percent of all expenditures.[18] Such calculations can be made for any educational program.

2.2.9 Opportunity costs. At all levels of education in less developed countries an important opportunity cost of educational systems is that students being educated are during that time kept away from work, as on the farm. Especially during harvests this cost may be so great that the schools must close. Instructional technology of certain sorts may permit more flexible scheduling than traditional schools, or even permit study at home, so decreasing such opportunity costs.

2.2.10 Start- and long-run costs. Over any short, current time period , most educational costs are fixed. In the immediate future--a year or so--the range of choices which an educational policy maker has before him are necessarily very limited. He has to pay teachers' salaries for the maintenance of his buildings, for school transport, for educational

materials, and instructional hardware and software, and for innumerable incidentals. He will be fortunate if he can use 5 percent of his annual budget for any innovative venture. Of course, the longer ahead he looks the greater is the range of his possible choices. Over a period of several years he can hire more or fewer teachers. He can use new media to a greater or lesser extent; he can build new buildings of different types for a multiplicity of purposes; and he can reorganize the personnel in the system. The nation as a whole, also, can allocate resources between education, on the one hand, and, say, health and welfare on the other, more freely as planning becomes longer and longer terms. Whenever an administrator makes a decision, however trivial, he limits the number of both short- and long-term choices he can make, because he commits some of his resources to a given path of development. A policy once inaugurated is hard to reverse. It therefore follows that an educational policy maker should have a long-term strategy in mind whenever he makes any decision which involves a significant commitment of resources.

3. Costs of Subsystems

If we are to compare the various subsystems of an educational system in terms of their costs, with or without one or more of the prostheses of the instructional technology media, we must arrive at agreement as to what are the subsystems or sectors of an educational system. Otherwise such cost comparisons cannot be made. We have suggested above that educational and other living systems have 19 subsystems (see pages 35, 38, 39, 40, 65-75, and 139-142). These may be looked on as programs, in the

traditional sense of program budgeting. Costs are the inputs or resources needed for such subsystems. Some of the types of costs discussed throughout this chapter are listed below. The subsystems with which they are associated are mentioned. (Not all 19 subsystems appear in this list, though they all have costs.):

Reproducer. These costs include the original planning, research, and development costs for the system and capital costs for hardware and the original software programming. These are the nonrecurrent start-up costs mentioned above.

Ingestor. Costs of recruiting personnel and obtaining equipment and supplies are included.

Distributor. These include the transportation costs for taking instructional materials and teachers to students or bringing students to them.

Producer. Costs for maintenance and upgrading of hardware and software are included.

Input transducer. Included are costs for re-educating teachers to use the media and upgrading their preparation; costs of obtaining new curricular ideas and new ideas about instructional hardware and software.

Internal transducer. Costs of formative evaluation are included here.

Channel and net. These include costs of communication, both face-to-face by the media.

Associator. These include the costs of the actual learning process of the students, with or without instructional equipment and of the salaries of teachers and others who help them in this learning process.

Memory. Included are the costs of workbooks, textbooks, libraries, and storage places for instructional materials.

Decider. The costs of administrative personnel and the supplies and facilities they use, such as a management information system, are included.

Output transducer. Included are the costs of public relations activities for the educational system with the rest of the society and certain broadcasting and publication activities.

A complete understanding of the costs of the total system requires an analysis of them by a program breakdown like the one above.

4. Conclusion

There is no better way to sum up this chapter than with the following quotation from Schramm, Coombs, Kahnert, and Lyle: [19]

"The extraordinary variability of the costs of new-media projects is apparent. To get into the educational media may cost anything from $5.5 million in capital outlay (for two channels of airborne television, serving a 400-mile circle) to $50,000 for a small service buying time on existing television facilities. An open-circuit installation with six channels may cost in excess of $2 million; a 'rental' closed-circuit installation with six channels, somewhere around $450,00. The median capital cost of a number of single-channel educational television stations was about $400,000. A small educational radio installation can be capitalized at somewhere around $50,000 plus the cost of receivers. The

capital costs of corresponding projects--except for the radio or television that may be connected with the project--are little more than the cost of office space and reproduction machines.

"Current costs (including capital charges) are just as variable--from $3 million annually for the airborne project to less than $100,000 for small radio and television services that do not own their facilities. School television costs from 5 to 60 cents per student-hour, depending on the size of audience, the amount and type of programming, and cost structure....

"Part of the variability of these costs depends upon salary and price structure. More of it, however, depends upon the size of the project, how large an audience it serves, and the cost-eff ciency of the balance between reception cost and production-transmission cost. Most of the projects we have observed underuse the media, and thus do not benefit from possible economies of scale. If they could expand their services to more users, or to more programmes, or to both, they could operate a great deal more cheaply in terms of unit cost. If receivers were used to a maximum, and with audience in the hundreds of thousands, it would be theoretically possible to reduce costs for instructional television broadcasting to as little as 1 to 5 cents per student-hour. Restrictions of population, schedule, and programme, however, will keep most of the operations below the peak of efficiency. Only in exceptional cases can we expect to go below 5 cents per student-hour for school television. Since our radio data are so limited, we hesitate to generalize, but it

looks as though radio costs per student-hour might be of the order of one-third to one-fifth as much as television used under comparable conditions. We have seen from the experience of several countries that correspondence-plus-broadcast teaching can be offered at a cost which is sometimes a little lower than, sometimes a little above, the ordinary cost of classroom instruction in densely populated areas.

"Do the new educational media save money? We pointed out that this is a very complex question, requiring one to measure quantitative cost against some things not so easily quantified--the quality of education, for example. Media projects will rarely save over present budgets, but often make possible a substantial saving in the context of growth and change--when a school system is planning to change a curriculum, offer new and different subjects, extend its services to persons or places where education has not before been available, or bring more people into the company of literate and educated persons. Even here, however, the saving is usually against possible or projected costs rather than present costs. Very often the media make it possible for a school system to do what it could not otherwise have done, regardless of cost; or to do faster what could otherwise have taken longer. And regardless of the quality of the evidence that they have saved financial resources, there is no doubt that they have contributed to the saving of human resources."

CHAPTER IV

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CHAPTER V

EFFECTIVENESS--THE MEASURES OF OUTPUTS FROM EDUCATIONAL SYSTEMS

1. Introduction

In the last chapter we saw that the methods developed by economists for measuring the costs of educational systems--the inputs or resources which they require to produce their outputs--are quite sophisticated. In this chapter we shall deal with measures of the effectiveness of educational systems, measures of their outputs. It will immediately become apparent that effectiveness measurement is far less advanced measurement. Indeed, until recent years there has been very little interest among educators in evaluating the effectiveness of educational systems either quantitatively or qualitatively. The need for such evaluation was not apparent to most educators. More than that there was much resistance against it. Before 1960 only the most primitive efforts were made to discover and agree upon indicators of the performance of educational systems which could be applied quantitatively to compare the performances of a given system at various times, or to compare the performances of alternative systems. Even at present the evaluation of the performance of educational systems is generally nonexistent or so feeble that most policy decisions made by educational administrators are based primarily on cost considerations rather than cost-effectiveness or input-output considerations. Many educators believe that it is difficult or impossible to measure the complex

subtleties of their professional activities and that any method purporting to do so would have obvious flaws in it. Others have argued that so many value judgments are involved in the measurement of educational effectiveness--values which differ between educators, between cultures, and between countries--that objective quantification is unattainable. For instance, Jamison and Suppes in discussing alternatives for improving productivity and efficiency in education stated that "clearly categorizing and measuring the outputs of an educational system is presently an impossible task."[1] In their view "much of the work that would be required in such an endeavor would involve assessment of values, not fact, and even if...(one) were to reach consensus, both the desirability and the capability of...(a government's) acting on this consensus are dubious."

The generally accepted procedure has been to make subjective judgments of the quality of various educational programs, often without much evidence. Many educators have implicitly or explicitly recognized that they differ markedly with each other in their judgments of quality, though some believe that outstanding excellence is clearly apparent to all. Under any circumstance, until recent crises in the financing of education, both in established and in less developed nations, drew their attention to the problem of cost-effectiveness, educators showed little concern about measuring it objectively.

All evaluation of educational programs, with or without the instructional technologies, should focus on providing an appropriate

learning environment to the individual student. The emphasis should not be on the teacher or the hardware. In attempting to compare the effectiveness of various educational systems for social development, it is necessary to create objective indices which can apply to all of them. Otherwise such comparative evaluation is impossible. Whatever method is used should be applicable to wholly human systems, that depend entirely on human beings, to mechanical systems using instructional hardware and software, and to mixed man-machine systems. In those systems which use instructional technology it should be considered an artifact that can serve as a prosthesis to aid the learning process. Responsible educators, faced by this new wealth of resources, will not want to continue traditional forms of education without comparing their cost-effectiveness with the alternatives now be coming available. Of each potential system we must ask such questions as: What can it do to cut the costs of education, or to improve its quality, or both? Under what circumstances is it desirable to employ one technology rather than another? How does each serve to accomplish the long-range or short-range goals of the system? Which contributes most to the individual student in the educational system, to the group in the classroom, to the school or university as an organization, to the society's educational system, or to international activities?

Generally, the instructional technologies should be viewed only as prostheses, aiding the organized human endeavor of educational systems. Sometimes and in some circumstances, however, these information

processing machines may serve as substitutes for teachers. For centuries now men, like the young Abraham Lincoln who to a large extent educated himself by books, have used scrolls or books to replace teachers or professors. More usually, however, instructional technology has represented a man-machine symbiosis--a mixed man-machine system. Automation can lighten the burden of the available qualified educators so that they can have time to deal with matters in which machines as yet are not very helpful such as improving their students' motivation to learn; supervising problem-solving by students; applying learned principles to real tasks in their own lives; developing students' manual dexterities; probing students' attitudes and feelings about what they learn; probing ethical, moral, and religious issues; making philosophical interpretations of the meaning of the knowledge which the students have acquired; and carrying out other functions which quite possibly machines may never be able to do. There is no challenge to man from the machine yet in most of these areas.

Ideally, educational innovation first should be employed in situations which permit comparative, controlled, and hopefully continuing cost-effectiveness evaluations. These should take into account cost as measured by the various indices discussed in the previous chapter. They should go beyond this, however, into the difficult realm of effectiveness evaluation. A number of questions about the effectiveness of any instructional technology have been suggested by the Subcommittee on Efficiency and Innovation in Education of the Committee for Economic Development:[2]

"Can the proposed technique be effectively employed in the cultivation of an open and inquiring mind? Or does it tend to produce conformity, dogmatism, and regimentation of thought?

"Is it capable of communicating and facilitating an understanding of complex concepts? Or is its usefulness limited to the management or manipulation of simple ideas?

"Is it capable of cultivating sensitive insight, originality, or analytical facility, and creative intellectual skills?

"Can it be employed to induce and deepen artistic and moral sensitivity and appreciation?"

"Do the benefits gained justify the costs incurred? Is the initial cost affordable?"

Educational benefits or effectiveness cannot be evaluated in anything but an unsophisticated and superficial way unless questions like those above are considered. Fortunately, modern engineering science has provided us with methods of measuring the effectiveness of hardware and, to some extent, of software systems. And statistics, educational psychology, and other behavioral sciences are beginning to supply us with a few effective, reliable, and valid instruments to measure the various influences of the learning process on human behavior, personality, and social interactions. Therefore we can reasonably hope that a reliable and valid science of evaluation practically useful to education will soon be developed for cost-effectiveness evaluation of alternative educational systems.

2. Research Relevant to Educational Evaluation

In 1969 a bibliography with 306 references on systems analysis for educational planning, including a number of papers concerning

cost-effectiveness analysis, was published by the Organization for Economic Cooperation and Development.[3] Several are referred to below. Many other studies have appeared during the past five years,

A general survey of cost-effectiveness analysis and of planning-programming-budgeting systems (PPBS) in education was made by Balderston and his associates.[4] Bloom and his associates have devoted much attention to the measurement of educational effectiveness being concerned primarily with the determination of educational objectives as well as the development, standardization, and administration of cognitive, affective, and behavioral tests in both formative and summative evaluation of the effectiveness of various sorts of educational programs.[5] Usually these are tests used in formal educational systems rather than as follow-up tests on graduates or alumni, or as tests for adults or others participating in nonformal education. But they may be used in such situations.

Gorth, Dumont, and Wightman at the University of Massachusetts have done important research on formative evaluation.[6] It concerns the testing of students at frequent intervals during instruction (e.g., every two weeks), as well as after instruction, with monitors or tests designed to evaluate achievement on each one of a set of previously specified objectives of the educational program. They refer to this as Comprehensive Achievement Monitoring. At each test administration performance is evaluated regarding (a) objectives not yet dealt with, (b) those just dealt with in the immediate past, and (c) those dealt with earlier in the course. Computer-based analyses and reports are given to teachers and students to aid them in developing curricula,

adapting study patterns, pacing and sequencing instruction, and improving the quality of education. Multiple variables of the learning process, including sociological variables such as family and social backgrounds of the students, school-related variables such as expenditures per student and urban or rural location, and student variables such as rates of learning and retention, personality, and vocational interest patterns, are analyzed by this approach.

Various approaches to summative evaluation have been researched. Woodhall, Goffman, and others have written about cost-benefit analysis.[7] This technique, developed chiefly by economists, views education as an investment by the individual student, his family, and his nation, yielding economic benefits to them and contributing to their future wealth by increasing the student's productive capacity. Educational inputs and outputs as well as costs and benefits are measured in the same monetary units. Economic calculations of different sorts can be used to determine the optimal educational program in cost-benefit terms. Hirsch and Marcus, for instance, have used cost-benefit calculations in an analysis of the desirability of universal junior college education in the United States.[8] This "econocentric" analytic approach seems too simplistic, since both the inputs to and the outputs from educational systems are of several sorts, not purely monetary. As Alkin, as well as Carpenter and Hoggart, point out, all aspects of systems cannot be measured in monetary units.[9]

One cost-benefit approach suggested by Blaug considers a less developed country's current and forecasted future manpower needs in addition to its finances.[10] He describes how cost-benefit analyses can be made in terms of how well the educational system meets the nation's needs for trained manpower, recognizing that a nation's educational system and labor market have reciprocal impacts.

Alkin proposes a model for cost-effectiveness summative evaluation of educational systems. As an improvement over cost-benefit analyses, the model includes "student inputs" (the characteristics of students entering the system); "educational inputs" (cognitive and noncognitive changes occuring after exposure to an instructional program); "financial inputs" (available financial resources for carrying on the program); "external systems" (the political, social, and legal structure of society); and "manipulable characteristics" (those aspects of the program which are resource-consuming and which are administratively manipulatable)."[11]

In recent years many other approaches to cost-effectiveness evaluation have been proposed. Most specialists agree that outputs of educational systems must be measured to determine their effectiveness. No single dimension is enough to measure those outputs. Many thoughtful persons interested in systems analysis have been challenged by the search for output indices which measure the quality of performance of an educational institution. Hanushek suggests that the quality of outputs of schools be measured by the percentage of students entering the school who complete each grade, the percentage who attend college, and their achievement scores.[12] Another set of measures for institutions

of higher learning is given by Turnbull.[13] These include:

Concerning students admitted--The percentage of students admitted. The percentage of the matriculants from the top quarter of the class. The level of admissions test scores. The propotion of National Merit scholars.

Concerning graduates--The percentage of alumni who go on to the best graduate and professional schools. The percentage who earn high awards. The percentage who get high-salaried jobs.

Concerning changes between admission and graduation--The average "value added" to students between input and output. The amount of learning or growth of students between their admission and their graduation.

Nonacademic measures of an institution's quality include:

- Its provision for self-goverance
- Its power to engender commitment to moral, social, and political causes
- Its respect for self-direction
- Its respect for expanding and transmitting human knowledge
- Research criteria such as the probability that its scholarship will advance knowledge importantly
- The strength of its ethical commitment of the graduates
- Service critiera like the extent to which it contributes to society

Brown outlined another approach to measuring the effectiveness or quality of the outputs of a university or other educational system.[14] First a set of goals or objectives for the system were identified, and measures were suggested.

He further outlined how each of the 20 measures can be given a weighting so that a total index of output effectiveness of the system can be calculated.

Beers follows a somewhat similar approach to the assessment of educational quality.[15] He stated 10 goals and produced sophisticated measures of the progress of the system toward their achievement. These were tests administered to fifth and eleventh grade students. The 10 goals were that quality education should help every child:

- Acquire the greatest possible understanding of himself and an appreciation of his worthiness as a member of society.
- Acquire understanding and appreciation of persons belonging to social, cultural, and ethnic groups different from his own.
- Acquire the fullest extent possible for his mastery of the basic skills in the use of words and numbers.
- Acquire a positive attitude toward school and toward the learning process.
- Acquire the habits and attitudes associated with responsible citizenship.
- Acquire good health habits and an understanding of the conditions necessary for the maintaining of physical and emotional well-being.
- Obtain encouragement to be creative in one or more fields of endeavor.
- Understand the opportunities open to him for preparing himself for a productive life and enable him to take full advantage of these opportunities.

- Understand and appreciate as much as he can of human achievement in the natural sciences, the social sciences, and the arts.
- Prepare for a world of rapid change and unforeseeable demands in which continuing education throughout his adult life should be a normal expectation.

The measuring instruments given to students to determine how well each goal was being achieved differed. The inventory used to assess fifth grade progress toward the first goal contained 53 test items, 47 from the Self-Esteem Inventory developed by Coopersmith and 6 from the Equality of Educational Opportunity survey developed by Coleman and his associates.

Rosenbaum and his associates on Task Force IV of the Connecticut Commission for Higher Education developed a relatively complex two-dimensional model for evaluating qualitative and quantitative performanc and achievement in higher education.[16] The flow of student population from precollege, through college, to postcollege is shown in Table 9. The top row represents the most naive approximation, based on simple numerical statistics. The analyses of each lower row are progressively more sophisticated, down to the bottom one designed to deal with qualitative considerations.

Definitions of the terms in the first row are listed below:

- Students potentially available--the size of the precollege population and the distribution of measurable abilities within identifiable segments of this group. Measurable abilities include new measures of students' unique talents which differ from the common aptitude and achievement scores that are presently weighted excessively in admission procedures.

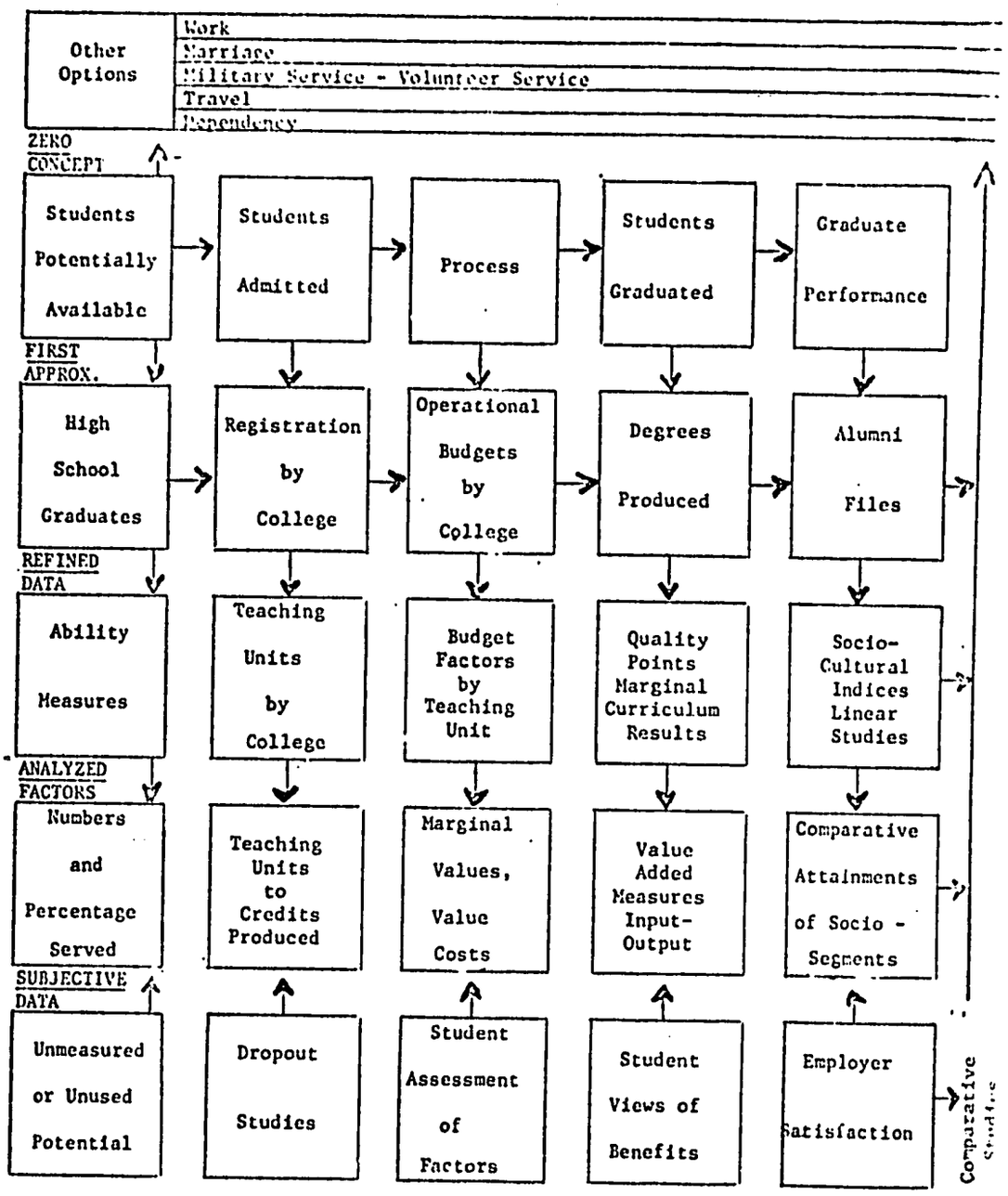

Table 9. Task Force IV Evaluation Model

(From Task Force IV, Connecticut Commission for Higher Education (R.A. Rosenbaum, Chairman). Qualitative and quantitative performance and achievement in higher education. Hartford, Conn.: Connecticut Commission for Higher Education (ERIC ED 048 833), January, 1971 9.)

- Students admitted--the characteristics of those who enter college: measurable abilities and demographic statistics.
- Process--a statistical analysis of the process of formal education including the size of faculty, administration, and staff; teaching loads; distribution by educational background, age, professional experience; class size; size and nature of facilities such as libraries, laboratories, classrooms, etc.; allocations of resources for general educational support like cultural events; psychological services; etc.
- Students graduated--the characteristics of those who leave college through graduation or otherwise; unit costs per academic credit earned, degree granted, and the like; attrition rates; postcollege plans. Specifically, "valued added" as measured by the development of students admitted, as distinct from general maturation which might occur without college.
- Graduate performance--characteristics of individuals five, ten, or more years after leaving college; differences between graduates and nongraduates, including in the latter group those who did not enter college.

In terms of this model, the goal of an evaluative procedure is to approach as closely as possible to the most refined approximation in the bottom row of Table 9. However, this does not mean that quantitative measures may be ignored. Rather it is expected that imaginative efforts will result in the evolution of numerical indices having good correlation with those qualitative characteristics of

successful education. The relative ease of amassing statistical data should not hide the importance of probing for the fundamental, tenuous, and often elusive qualities of effective higher education.

The cost-effectiveness from an engineering viewpoint as well as the educational effectiveness of a technological system for instructional use can be evaluated. The Stanford Electronics Laboratories studies have developed models and computer programs for the comparative evaluation of alternative terrestrial, celestial, and mixed communications systems for instructional technolgoy.[17] The final measure of cost-effectiveness of an educational system employing such communications is a complex joint function of the measures of educational and engineering cost-effectiveness.

The use of mathematical models and computer simulations of educational systems is another research approach to cost-effectiveness evaluation. Bell reviewed this approach for the Carnigie Commission on Higher Education.[18] Models and simulations by Koenig, Weathersby, Judy, and many others most likely can be used to improve the cost-effectiveness of educational systems. One must, however, keep in mind that they have many weaknesses and shortcomings.

The follow-up study of "Sesame Street" is a major example of cost-effectiveness evaluations.[19] This program now is being exported from the United States, either as originally produced or in translated or re-enacted formats to other nations including Mexico, Germany, and Brazil.

The less developed nations have rarely been considered in the above research, although a great deal of it is applicable to their problems. Some educational evaluation studies in less developed countries have been conducted although most of them have been carried out in established nations. One is a carefully designed experiment on the use of midcourse feedback to improve a program using television. An evaluation program was begun in 1970 of the El Salvador television project. Tests were designed for seventh grade mathematics and social studies. They were administered by TV to all seventh grade classes. A research team from Stanford's Institute for Communication Research observed the tests being given and then intensively analyzed the data from 14 classes.[20] This study provided answers to their questions.

Procedures were established for obtaining short-range, yet detailed information on student learning from television. This information helped the television production personnel identify concepts that had not been adequately learned by students within a specific unit of material. Limited corrective action was undertaken by the subject-area teams to remedy the learning deficiences, but more could have been done along this line. The teachers and students favored the use of such tests although they had little direct impact on the quality of the programs produced.

The Stanford group identified six problems that would have to be addressed in any further research and development on feedback systems in El Salvador. These include:

- The lack of training or experience in modern test construction among educators in that country.
- A severe limitation on the number of letters that can be presented at any one time in tests administered on the TV screen.
- The optimal duration of presentation of TV test questions.
- The most rapid and efficient collection of test results.
- Application of feedbacks to improve program quality.
- Making just the right amount of adjustment in programs in the light of formative evaluation feedbacks.

The El Salvador experiment has indicated that feedbacks concerning new curricula can be obtained for purposes of formative evaluation. What the best means of feedback are, how this feedback can be translated into better programming, how a feedback system can be expanded to include direct indications to learners and classroom teachers of learning outcomes, and how costly a thorough feedback system would be are questions that need to be answered. In El Salvador testing is done by TV. There is no convincing evidence whether or not this is the best way to give tests for formative evaluation. Research and development are needed on alternative means of obtaining feedback. In less developed countries the large gap between the desired speed of response and the actual conditions of communication suggests that further work is necessary to ensure that the responses are fed back to program producers to be useful. The need to train curriculum producers to make constructive use of the feedback information they get is equally important. The urgency to prepare lessons in time often prevented the programmers from considering and acting upon the results of the evaluation adequately.

Speagle conducted a summative cost-effectiveness evaluation of the El Salvador educational TV project.[21] He analyzed its budget and the available measures of its impact. He estimated that the program in junior high schools raised costs per student 15 percent, but he concluded that expansion of the program should reduce per student costs. There have not yet been any large-scale improvements in student learning derived solely from TV. Use of TV had produced significant savings, however, because it justified cutting down the retraining period of junior high school students from two years to one year. Speagle concluded that cost-effectiveness would not clearly rise until the student-teacher ratio is increased or changes are made such as also using the TV system for teacher training or adult education, thus leading to greater productivity are made.

Cost-effectiveness studies have been carried out by Blaug, Layard, and Woodhall, and by Nalla Gouden in India; by Schultz and Carnoy in Latin America; and by Smyth and Bennett in Uganda.[22] They all showed that the benefits to the society per unit cost from primary education were greater than from secondary or higher education. A cost-benefit study done in Japan made it clear that one specific alternative form of technical education was much preferable to another.[23]

A Brazilian survey of evaluation of the use of educational technology and the development of nonformal alternatives and supplements revealed that often although people are assigned to do evaluations, their efforts do not yield the sort of information which can lead to

specific changes in instructional programs.[24] Most evaluations emphasized description of the audience reached by a given project. Such emphasis on static description often neglects crucial issues like the following:

- Is the audience actually reached the same as the planned target audience, or is it an entirely different population? Nonformal education often reaches the same people that could be trained by formal education.

- Is the audience being changed in any important way by the program, or is it not causing effective learning?

- Are the instructional procedures attuned to the culture and to the ethnographic characteristics of the target audience? Or is it assumed that one set of instructional procedures can be similarly effective with all potential learners in a large and complex nation? The admirable idealism of a unified Brazil is compatible with the providing of differentiated learning experiences, which are tailored to the backgrounds of learners. Ignoring this problem will produce highly discriminatory educational curricula in which the masses will often be asked to accommodate themselves to the standards and characteristics of the educated minority.

- To what extent is the content of education relevant to the vital needs of the various target audiences? Is it assumed that high quality education is the same for everyone? Despite the Brazilian Education Reform Law, serious miscalculations of the learning potentialities of the masses are likely to occur.

Gradually it is being recognized by top educators in Brazil, partly through the impact of SATE, the agency planning educational evaluations throughout the country, that questions like the foregoing are central to the evaluation process.

Wolff has discussed another aspect of cost-effectiveness evaluation of Brazilian schools.[25] Data on student enrollment and repetition of grades by students in primary schools which were reported by the schools of each state to the Ministry of Education and Culture were used. From these he calculated an estimate of "school efficiency"--the fraction of children entering primary school who complete the full course. The Brazilian states differed widely on this index of effectiveness. States with high per capita incomes, like Sao Paulo, Guanabara, and Rio Grande do Sul, had high scores on school efficiency, and those with low per capita incomes, like Acre, Maranhao, and Amazonas, had low scores. Wolff had no data on the relation of the use of instructional technology to school efficiency. Its use in Brazil is not yet so widespread that such data would be particularly useful.

Some research on educational evaluation is being undertaken in other countries like Niger, the Ivory Coast, and Korea, but this work is not far advanced.

A rapid acceleration of interest has occurred among social scientists and some government officials in the last five years in social indicators of the cost-effectiveness of the various major sectors of a nation.[26] Interest has also increased in developing organizational

indicators of the cost-effectiveness of the main subsystems of many diverse profit and nonprofit organizations, including corporations, government agencies, hospitals, schools, farms, universities, courts, welfare agencies, prisons, and so forth.[27]

The above review of research covers only a few studies in the field. A science of the evaluation of organizations is beginning to emerge which will probably be applicable across various types of organizations. Much more methodological research must be conducted before this is a full-fledged scientific field capable of rigorous application.

3. Procedures for Measuring the Effectiveness of Educational Systems

Previously in this report we have employed two related but different terms (see page 51), efficiency and effectiveness. Efficiency refers ordinarily to the cheapness of costs and adequacy of performance of a subsystem or component of a system. This may be a purely human subsystem or component, or it may involve instructional technology. For instance, the channel and net subsystem may employ a wide range of broadcasts and other communications technologies; the associator subsystem may use various of the small media, books, workbooks, radio, television, or computer-aided instruction; and the decider subsystem may employ a computerized information system for management, planning, and evaluation. A study can be made as to whether these technologies, when added to the subsystem or component, raise or lower the costs of

operation and decrease or increase their performance. On the other hand, effectiveness ordinarily refers to the external impact of a system upon its environment or suprasystem. This may be measured by comparing the test performance of students when they enter an educational system with their performance and when they leave it--a training criterion. Or it may be measured by their performance after they enter the society or their economic or other impact or influence on the society. The evaluation of a subsystem's performance, using feedbacks to improve it, often is referred to as formative evaluation, while the evaluation of the performance, productivity, or influence upon the external society of the total system, using feedbacks to improve it, often is known as summative evaluation.

Figure 3 is a diagram of the associator subsystem (or educational sector) and the decider subsystem (or government) of a society such as a less developed country. The associator subsystem includes, in addition to the formal primary, secondary, and higher education systems, all the nonformal situations in which learning occurs, which are usually or always more important. A few of the many subsubsystems which go to make up the associator subsystem or educational sector of the society are included in the diagram--the channel and net subsubsystem, the associator subsubsystem, and the decider subsubsystem particularly. Through these pass solid-line arrows representing matter-energy flows and dashed-line arrows representing information flows. These flows occur in all subsystems and subsystems of living systems, because they are input-output systems just as the total system is. In addition the various subsubsystems have information feedbacks. These are the formative evaluation feedbacks by which the

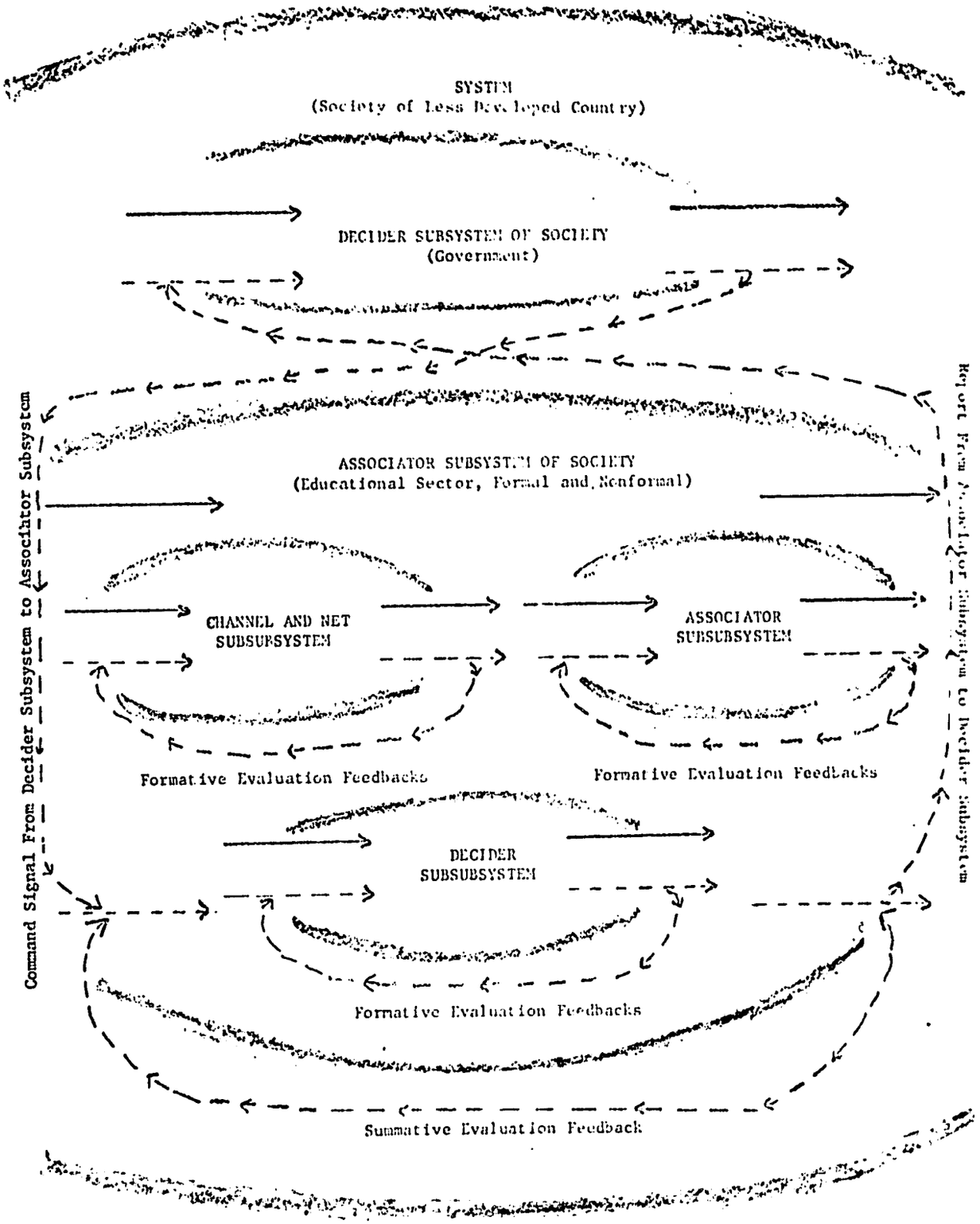

Figure 3. The Associator Subsystem (or Educational Sector) and the Decider Subsystem (or Government) of a Society (or Less Developed Country), Indicating Main Inputs, Outputs, and Feedbacks for Evaluation of Effectiveness of the Educational Process. (Matter-Energy Transmissions are Represented by Solid Lines; Information Transmissions are Represented by Dashed Lines; Formative Evaluations Feedbacks are Internal Within Associator Subsystem; Summative Evaluation Feedback is External to Associator Subsystem.)

efficiency of these various subsubsystems is measured. The overall summative evaluations of the total system are indicated by the feedback from the output back to the input of the total associator subsystem. Also information signals go from the decider subsystem of the society and are input to control the society's associator subsystem or educational sector. And other signals are output from the associator subsystem and input to the decider subsystem, reporting on the associator's performance.

With this general conceptual diagram in mind, connecting our present discussion with our overall general systems orientation, we can proceed to a consideration of each of the steps which must be taken in a sophisticated evaluation of a nation's educational system:

3.1 Manpower analysis of the society. Before any extensive planning of the system is carried out, and certainly before it is operated, it is desirable to make a manpower analysis of the society, a total national assessment. Educational planners should know first of all how many individuals there are with each level and specialty of education in the entire country. In addition an estimate, as careful as possible, should be made of the country's needs for each of these categories of educated personnel with projections made into the future ten or twenty years. Such projections involve complicated calculations of the expected population trends over the coming years as well as of expected shifts in agriculture industry, and other categories of economic activity. Such "market evaluation" of the educational system is much easier described than done. No nation has yet done an adequate job of it. Analyses of this sort need constantly to be updated because the society is in constant

change. Nevertheless, effective planning of an educational system must take demographic variables into consideration. Furthermore, if educational progress of a nation is to be measured over a period of time, its baseline measurements must be made at the beginning of that period. One ambitious program of this sort in the United States is the National Assessment of Educational Progress. This is an information-gathering activity designed to find what young people know and can do in ten subject areas commonly taught in American schools: citizenship, science, writing, reading, literature, mathematics, social studies, music, art, and career and occupational development. This program is designed to describe, for educational administrators and the public of the United States the educational attainments of the country's young people. It is planned, then, to measure any growth or decline in these accomplishments over a period of time. In addition the data can be broken down for various educational specialties and by such demographic categories as regions of the country, size and type of community, race, sex, and parents' educational attainments.

3.2. Objectives. On the basis of such a manpower analysis, planners for the national educational system can proceed to set quantitative goals as to the number of persons who should receive each course of education during each specific period. Priorities can also be set for those regions and subject areas in which the society appears to have the greatest quantitative need.

In addition to quantitative objectives, qualititative objectives can be established. A great deal of technical work, notably by Bloom and his associates, has gone into the development of educational objectives and

measures for them.[28] They and others divide the objectives of education into three domains in their taxonomy of educational objectives: the cognitive or intellectual, the affective or emotional, and the psychomotor or behavioral.[29] The cognitive domain is subdivided into the following categories: knowledge, comprehension, application, analysis, synthesis, and evaluation. The affective domain is divided into receiving or attending, responding, valuing, organizing, and characterizing by a value or value complex. The psychomotor domain could be subdivided also, but has not yet been studied so extensively.

Under each of these categories the specific objectives of the given educational system should be stated as operationally as possible. Then tests can be prepared and evaluated for reliability and validity, which can be used to measure progress toward these objectives. Much work has been devoted by experts in educational testing to the preparation of such tests, and indeed the psychometric skills required in their development constitute a subspeciality.

One presentation of such objectives together with a statement of possible measures of them, has been made by Brown, a practicing educator and educational administrator.[30] First of all he states the characteristics which he believes these measures must have:[31]

"(1) Quantifiability. Output must be stated in objective, quantifiable units."

"(2) Additivity. The output in Category "1" (i.e., whole man) and the output in Categories "2-5" must be stated in the same units so that total output may be summed.

"(3) Divisibility. The measures selected for the system as a whole (American Higher Education) must be equally available and meaningful for subsystems such as private versus public higher education, higher education in the state, XYZ University, the College of Law at XYZ, and a particular activity within the XYZ Law School.

"(4) Transferability. The measurement system appropriate for 4-year colleges must also be appropriate for universities and for junior colleges.

"(5) Consensus Acceptability. The measures should be credible. A majority of all constituencies--students, faculty, public, private--should agree that the measures are not inappropriate.

"(6) Flexibility. To the extent that consensus acceptability of goals and measures cannot be achieved, model users must be provided with 'mix and match' output measures. A state planner, for example, may wish to measure change in tax revenues due to higher education and would, therefore, prefer 'change in lifetime income' to measure output. A scholar may, on the other hand, wish to measure disciplinism or growth of the mind and, therefore prefer 'change in percentage intending to attend graduate school' or 'change in IQ.' The point is that the model must be flexible so that users with different purposes and with different values can employ it for their own purposes. Each goal must be measurable by several means."

Then Brown proceeds to state a set of goals or objectives which he believes are applicable to systems of higher education (but could also be applicable to the students in primary and secondary education). For each objective he lists some suggested measures (see Table 10).[32]

GOAL OR OBJECTIVE	SUGGESTED MEASURE(S)
A. Learn to Feel	1. Student Testimony* (e.g., student's answer to question, "Has college increased your sensitivity to the problems of others and your appreciation for classical music by: 'a great deal,' 'a modest amount,' 'not at all,' or 'decreased'?")
B. Learn to Retain Facts	2. Student Testimony* (e.g., "While in college has your factual knowledge: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
	3. Difference between percentile rank on GRE (or substitute exam) and percentile rank on SAT or ACT.
	4. Difference between "before" and "after" reading-listening test on totally new material.
C. Learn to Think	5. Student Testimony* (e.g., "While in college your logic and reasoning abilities have: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
	6. Difference between "before" and "after" score on Miller Analogy Test.
D. Learn to Decide	7. Student Testimony* (e.g., "While in college your ability to choose alternatives, to reject some life styles, and to choose wisely: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
	8. Difference between "before" and "after" item analysis of College Student Questionnaire.
E. Learn to Act	9. Student Testimony* (e.g., "While in college has your effectiveness in communicating ideas to others: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
F. Learn to Learn	10. Student Testimony* (e.g., "While in college have you increased your ability and your motivation to learn on your own, to be a self-starter by: 'a great deal,' 'a modest amount,' 'not at all,' or 'decreased'?")

11. Difference between "before" and "after" item analysis of College Student Questionnaire on questions such as, "How many books did you voluntarily read in the last six months?"
12. Difference between "before" and "after" score on an artificial language test.

G. Choose a Career

13. Student Testimony* (e.g., "In *selecting* a career, attending college helped: 'a great deal,' 'a modest amount,' 'not at all,' or 'negative influence'?")
14. Per cent of students who identified or altered specific career goal while in college, as measured by "before" and "after" samplings.

H. Gain Admission to Next Stage in Career

15. Student Testimony* (e.g., "Did college move you along toward your career goal: 'a great deal,' 'a modest amount,' 'not at all' or 'negative influence'?")
16. Change in per cent declaring graduate school (or medical or law schools) intention "before" and "after."

I. Develop Skills of One's Chosen Profession

17. Student Testimony* (e.g., "While in college your proficiency in the skills of your chosen profession: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
18. Difference between "before" and "after" percentage of students passing specific professional examinations such as the Bar Exam or the CPA Exam.
19. Number of pages published by graduate school graduates in scholarly journals.
20. Difference between Cartter rating of school of undergraduate enrollment and of first job (applicable to graduate students only).

J. Earn a Living

21. Student Testimony* (e.g., "While in college my ability to earn an acceptable living: 'more than doubled,' 'increased some,' 'remained about the same,' or 'decreased'?")
22. Ratio of starting salary of age cohort of college graduates versus matched pair (by ability and background) of persons who did not attend college.

K. Fulfill Society's Manpower Needs

23. Student Testimony* (e.g., "While in college my ability meaningfully to contribute to the manpower needs of the nation and society increased by: 'a great deal,' 'a modest amount,' 'not at all,' or 'decreased'?")

L. Identify New Phenomena	24. Faculty Testimony* (e.g., "During last year your most significant discovery will desirably alter the course of history: 'a great deal,' 'a modest amount,' 'not at all,' or 'in a negative way'?")
	25. Number of dollars received from new patents.
M. Synthesize and Summarize in New Ways	26. Faculty Testimony* (e.g., "During last year did your research and study result in a new synthesis or summary that will desirably alter the course of history: 'a great deal,' 'a modest amount,' 'not at all,' or 'in a negative way'?")
N. Communicate New Knowledge	27. Faculty Testimony* (e.g., "Your thinking and writing during the last year has stimulated professional colleagues: 'a great deal, 'a modest amount,' 'not at all,' or 'negatively'?")
	28. Number of pages published in scholarly journals and books during the last year.
O. Relate Knowledge to Societal Problems	29. Faculty Testimony* (e.g., "During the last year personal consultation assisted in the solution of important societal problems: 'a great deal,' 'a modest amount,' 'not at all,' or 'a negative effect'?")
	30. Number of days spent consulting (paid and unpaid) last year.
P. Carry Out Societal Project	31. Faculty Testimony* (e.g., "During the last year my hours devoted to implementing a society-aiding project contributed to the success of that project: 'a great deal,' 'a modest amount,' 'not at all,' or 'negatively'?")
	32. Number "graduated" from funded training programs.
Q. Evaluate Effectiveness of Current Attacks on Problems	33. Faculty Testimony* (e.g., "During the last year my role in evaluating the effectiveness of various projects designed to better society was: 'a great deal,' 'a modest amount,' 'not at all,' or 'negative'?")
R. Increase Dignity and Self-esteem of Faculty	34. Faculty Testimony* (e.g., "During the past year my image of myself and my colleagues has grown: 'a great deal,' 'a modest amount,' 'not at all,' or 'decreased'?")

	35. Percentage change in compensation divided by percentage change in income for entire U. S.
S. Increase Student Enjoyment While in College	36. Student Testimony* (e.g., "While in college you had: 'a great time,' 'a good time,' 'little or no enjoyment,' or 'a miserable time'?")
	37. Per cent intending to donate after college "before enrolling" versus per cent intending to donate (or donating) "after graduating."
T. Provide Benefits to Town Citizens	38. Faculty Testimony* (e.g., "During the past year town residents not directly associated with the university benefited from the university's presence: 'a great deal,' 'a modest amount,' 'not at all,' or 'negatively'?")
	39. Change in number of part-time students enrolled.
	40. Change in number of public lectures and performances given.

*Student (faculty) testimony might include not only the assessment of self-growth but also the growth of the student's (faculty's) best friend. Thus, an alternate to the question at measure one might be "Has college increased your best friend's sensitivity . . . ?"

Table 10. Measures for Educational Goals.

(From D. G. Brown. A scheme for measuring the output of higher education. In B. Lawrence, G. Weathersby, and V. W. Patterson (Eds.) The outputs of higher education. Boulder, Colorado: Western Interstate Commission for Higher Education. July, 1970, 27-38.)

3.3 Constraints upon the system. It is impossible to make an objective analysis of the effectiveness of any system or to compare it with the effectiveness of alternate systems unless there is an explicit statement as to what specific constraints are exerted upon the system. In every real situation there are such constraints. A classification of the constraints upon educational systems--small and large systems, with or without instructional technology--appears below. Specific data as to which of these constraints exist, and to what degree, should be obtained during the planning process. The classes of constraints are:

(1) Financial or budgetary

(2) Temporal limits of the program

(3) Geographical limits of the program

(4) Institutional role in the society

(5) Target student population

- (a) Size of population
- (b) Ages
- (c) Sexes
- (d) Previous knowledge and skill of students
- (e) Socioeconomic statuses
- (f) Ethnic groupings
- (g) Languages used in instruction

(6) Characteristics of instructional media used

- (a) Context of reception (e.g., classroom, individual study, home study)
- (b) Motivational characteristics
- (c) Portability of medium
- (d) Type of control (e.g., by teacher, by student)
- (e) Sensory modality (e.g., audio, visual, both)
- (f) Ability to provide "branching" of content
- (g) Ability to provide rapid, individualized feedback to the student on the correctness or error of his responses

(7) Content

(8) Style of programming

(9) Duration of instruction

(10) Quantity of manpower required

(11) Quality of manpower required

(12) Political

(13) Cultural and social

(14) Legal

(15) Hardware and physical facilities

(a) Reliability
(b) Maintenance requirements
(c) Availability of power

(16) Current organizational structure of educational system

(17) Amount of related expertise or research results available

3.4 Variables. If the effectiveness of any educational or other organization is to be evaluated, an organizational inventory of each of its subsystems or components must be carried out. Such inventories are getting increasing attention in the field of organization theory. One example is the work of Taylor and Bowers who developed an organizational inventory designed primarily for business corporations. It included measures of supervisory leadership, organizational climate, and workers' satisfaction.[33] Many comparable efforts have been made to carry out organizational inventories. Fundamentally the procedure is like a physical examination of a human being:

(1) First one must have a complete listing of the subsystems or components which make up the system. In clinical medicine there is general agreement of what these are.

(2) Then each of these subsystems or components in order is examined as to the status of several variables. A test is made to determine whether each of these variables (and input-output variables of the systems as a whole) is within, or outside of, a normal steady-state range. Those that are outside of the normal range are recorded as pathological.

(3) After this is done for each subsystem or component and all the abnormal findings have been discovered, an effort is made to look at them as a totality and, from their configuration or interrelationships, to diagnose a syndrome of abnormal performance.

(4) Once such a diagnosis is made, various steps may be taken to correct the pathology. Structural changes may be made in the system (changes in the table of organization). Functional alterations may be made (e.g., changing the number or type of personnel in various subsystems or components). Prostheses or technology may be added to improve the functioning of certain subsystems or components.

Thus there is diagnosis and treatment, and, in educational systems the treatment of choice is the optimal instructional strategy, with or without the use of instructional technology.

3.4.1 Subsystem variables. From our conceptual system discussed in Chapter I, the following variables, listed by subsystems, can be derived, which can be employed in the inventory of the cost-effectiveness of any educational or other organization:

Reproducer variables: Sorts of matter-energy used in reproducing; meaning of information used in reproducing; sorts of information used in

reproducing; changes in reproducing over time; changes in reproducing with different circumstances; rate of reproducing; frequency of reproducing; lag in reproducing; costs of reproducing.

Boundary variables: Sorts of matter-energy crossing the boundary; meaning of information crossing the boundary; sorts of information crossing the boundary; degree of permeability of the boundary to matter-energy; degree of permeability of the boundary to information; percentage of matter-energy arriving at the boundary which enters the system; percentage of information arriving at the boundary which enters the system; changes in matter-energy processing at the boundary over time; changes in information processing at the boundary over time; changes in matter-energy processing at the boundary with different circumstances; changes in information processing at the boundary with different circumstances; rate of matter-energy processing at the boundary; rate of information processing at the boundary; frequency of matter-energy processing at the boundary; frequency of information processing at the boundary; lag in matter-energy processing at the boundary; lag in information processing at the boundary; costs of matter-energy processing at the boundary; costs of information processing at the boundary.

Ingestor variables: Sorts of matter-energy ingested; degree of openness of the ingestor; changes in ingesting over time; changes in ingesting with different circumstances; rate of ingesting; frequency of ingesting; lag in ingesting; costs of ingesting.

Distributor variables: Sorts of matter-energy distributed to various parts of the system; changes in distributing over time; changes in distributing with different circumstances; rate of distributing; frequency of distributing; lag in distributing; costs of distributing.

Converter variables: Sorts of matter-energy converted; percentage of matter-energy converted; changes in converting over time; changes in converting with different circumstances; rate of converting; frequency of converting; lag in converting; costs of converting.

Producer variables: Sorts of matter-energy produced; quality of matter-energy produced; percentage of matter-energy used in producing; changes in producing over time; changes in producing with different circumstances; rate of producing; frequency of producing; lag in producing; costs of producing.

Matter-energy storage variables: Sorts of matter-energy stored; total storage capacity; percentage of matter-energy stored; place of storage; changes in storing over time; changes in storing with different circumstances; rate of storing; lag in storing; costs of storing; rate of breakdown of organization of matter-energy in storage; sorts of matter-energy retrieved; percentage of matter-energy retrieved; order of retrieval; rate of retrieval; lag in retrieval; costs of retrieval.

Extruder variables: Sorts of products and wastes extruded; percentage of products and wastes extruded; changes in extruding over time; changes in extruding with different circumstances; rate of extruding; frequency of extruding; lag in extruding; costs of extruding.

Motor variables: Sorts of movements made; changes in moving over time; changes in moving with different circumstances; rate of moving; rate of output of work; frequency of moving; duration of moving; lag in moving; costs of moving.

Supporter variables: Strength of the supporter; costs of supporting.

Input transducer variables: Meaning of information input which is transduced; sorts of information input which are transduced; percentage of the information input which is transduced; threshold of the input transducer; changes in input transducing over time; changes in input transducing with different circumstances; channel capacity of the input transducer; number of channels in use in the input transducer; distortion of the input transducer; signal-to-noise ratio of the input transducer; rate of input transducing; lag in input transducing; costs of input transducing.

Internal transducer variables: Meaning of internal information which is transduced; sorts of internal information which are transduced; percentage of the internal information which is transduced; threshold of the internal transducer; changes in internal transducing over time; changes in internal transducing with different circumstances; channel capacity of the internal transducer; number of channels in use in the internal transducer; distortion of the internal transducer; signal-to-noise ratio of the internal transducer; rate of internal transducing; lag in internal transducing; costs of internal transducing.

Channel and net variables: Meaning of information channeled to various parts of the system; sorts of information channeled to various parts of the

system; percentage of information arriving at the appropriate receiver in the channel and net; threshold of the channel and net; changes in channel and net processing over time; changes in channel and net processing with different circumstances; information capacity of the channel and net; distortion of the channel and net; signal-to-noise ratio in the channel and net; rate of processing of information over the channel and net; lag in channel and net processing; costs of channel and net processing.

Decoder variables: Meaning of information which is decoded; sorts of information which are decoded; percentage of the information input which is decoded; threshold of the decoder; changes in decoding over time; changes in decoding with different circumstances; channel capacity of the decoder; distortion of the decoder; signal-to-noise ratio of the decoder; rate of decoding; percentage of omissions in decoding; percentage of errors in decoding; codes employed; redundancy of the codes employed; lag in decoding; costs of decoding.

Associator variables: Meaning of information which is associated; sorts of information which are associated; percentage of the information input which is associated to other information; changes in associating over time; changes in associating with different circumstances; channel capacity of the associator; rate of associating; lag in associating; costs of associating.

Memory variables: Meaning of information stored in memory; sorts of information stored in memory; total memory capacity; percentage of information input stored; changes in remembering over time; changes in remembering with different circumstances; rate of reading into memory; lag in reading

into memory; costs of reading into memory; rate of distortion of information during storage; time information is in storage before being forgotten; sorts of information retrieved; percentage of stored information retrieved from memory; order of retrieval from memory; rate of retrieval from memory; lag in retrieval from memory; costs of retrieval from memory.

Decider variables: Meaning of information employed in deciding; sorts of information employed in deciding; amount of information employed in deciding; changes in deciding over time; changes in deciding with different circumstances; number of alternatives in input before decision and in output afterwards; rewards and punishments attached to alternatives reviewed in deciding; rate of deciding; lag in deciding; costs of deciding.

Encoder variables: Meaning of information which is encoded; sorts of information which are encoded; changes in encoding over time; changes in encoding with different circumstances; channel capacity of the encoder; distortion of the encoder; rate of encoding; rate of encoding; percentage of omissions in encoding; percentage of errors in encoding; code employed; redundancy of the code employed; lag in encoding; costs of encoding.

Output transducer variables: Meaning of information output which is transduced; sorts of information output which are transduced; changes in output transducing with different circumstances; changes in output transducing over time; channel capacity of the output transducer; number of channels in use in the output transducer; distortion of output transducer; rate of output transducing; lag in output transducing; costs of output transducing.

3.4.2 Variables of educational systems. These may be divided into internal or subsystem variables measuring efficiency, and external or total system variables measuring effectiveness. Examples of the former are: class hours per student per year; school days per year; learning rate per student; and average student satisfaction with educational experience. All of these are measures of the internal efficiency of one or another subsystem or component, and formative evaluation is designed to improve such efficiency.

On the other hand there are external variables of total system effectiveness or impact upon the society. Some of these are training criteria measured by comparisons of pretests before education begins with tests during education, and posttests at the end of education. Others are performance criteria measured by tests after the student becomes an alumnus and goes into the society (or suprasystem). These tests evaluate both the effects of his education on him as an individual and also the effects of the total educational system on the society. Among the variables such tests can measure are: jobs per alumnus; gross national product; industrial productivity of the society; agricultural productivity of the society; total number of libraries in the society; ratio of the number of children per family of alumni to the number of children per family in the society; ratio income per year per alumnus at a given time after graduation to income per year per person for the society; ratio of income spread per alumnus to income spread for the society; ratio of work satisfaction per alumnus to work satisfaction for the society; subjective quality of life for alumni as compared to

subjective quality of life for the society; ratio of doctor visits per capita for the alumni to doctor visits per capita for the society; ratio of morbidity per capita for the alumni to morbidity per capita for the society; ratio of mortality per capita for the alumni to mortality per capita for the society; ratio of toilets per capita for the alumni to toilets per capita for the society; ratio of houses per capita for the alumni to houses per capita for the society; ratio of books owned per capita by the alumni to books owned per capita by the society; and ratio of TV sets owned per capita by the alumni to TV sets owned per capita by the society. All of these are measures of the effectiveness of the total educational system, and summative evaluation is designed to improve such effectiveness.

3.5 Tests of variables. We have already stated that these tests can be administered before the beginning of the educational process to provide a baseline, during education, at its end, and after the student becomes an alumnus and goes into the society. They can also, for purposes of scientific evaluation, be given to control groups who do not receive the educational experience, or to a sample of the total society, the test findings then being compared against the findings for the educated alumni. The tests of cognitive, affective, attitudinal, behavioral, and other results of education are very numerous indeed. They have been described and categorized at length in many publications.[34] They can be provided for all levels of instructional advancement and for many content areas. Often they can be translated and adapted for administration in different countries, but much care must be taken in using such adaptations because they may not be culture fair and the norms for one country

may not apply to another. There are many other problems involved in the use and the statistical analysis of the results of such tests, but they are essential if the effectiveness of educational systems is to be scientifically evaluated.

3.6 Simulation. For planning purposes computer simulation of the educational system may be desirable. Once its subsystems have been identified and their variables measured, the input data for such a simulation are available. When the simulation is operating, the effects of changing to alternative human and technological configurations may be analyzed. If, for example, there is a shortage of qualified teaching personnel, then the use of paraprofessionals plus instructional technology could be simulated as an alternative way to carry out the processes of the associator subsystem. If it appears that decisions are being made slowly and poorly, the use of a computerized management information system by the subsystem can be simulated. If simulation reveals that there is likely to be a breakdown in the delivery of storage batteries to power local television sets receiving educational programs from satellites, then an addition of more trucks and/or personnel to the distributor subsystem may be considered. And so forth.

3.7 Chronogram or PERT diagram. These are two ways of dealing with the time dimension in planning the educational system and then carrying out the various steps necessary to develop and operate it. It is essential that, as part of the planning process, a carefully worked out schedule be developed. The temporal as well as the spatial dimensions of an educational program must be considered not only in the general planning activities but also in any simulation that may be used.

3.8 Operations. Once operations of the system begin, evaluation must be a continuing and permanent aspect of them. This is essential if the system is to remain effective and adjust to the many changes that occur in the society around it as well as those within it. This means that evaluation units must be formed well before operations begin. These must begin by establishing objectives and making baseline measurements with which later tests of subsystem or component variables will be compared. These units should constantly strive to improve their instruments for making their tests objective, impartial, reliable, valid, and adequate to their purposes. Then they should establish a procedure for conducting formative evaluations of various subsystem functions and summative evaluations of the total system on a regular schedule thereafter.

4. Engineering Efficiency or Effectiveness of Prostheses in Educational Systems

We have recognized that one treatment of a national educational system which can improve its functioning is to incorporate instructional technology artifacts serving as prostheses into the system. These can be designed to increase the engineering efficiency of one or more of its subsystems or the engineering effectiveness of the total system. The practical procedure for selecting among several possible alternative systems using instructional technology is to make a sort of regression analysis of the various weighted effects, on the total system input-output performance, of changes in the engineering effectiveness of

alternative prostheses that can be used in the system, plus alternative changes in the educational process itself. Prostheses may be used to improve engineering efficiency of several subsystems of the educational system, as we have indicated above, but they are used especially in the channel and net subsystem, the associator subsystem, the memory subsystem, and the decider subsystem. On the other hand, changes in educational procedures improve the efficiency of the associator subsystem almost exclusively.

Appendix I is a comparison of the engineering effectiveness of four alternative educational systems which might be employed in India: Conventional rebroadcast stations with terrestrial microwave interconnection; satellite broadcast exclusively; conventional rebroadcast stations with satellite interconnection; or a hybrid system with five rebroadcast stations. This 1968 analysis made some basic calculations comparing these alternatives, but neglected many aspects of evaluation we have mentioned above. Appendix II is a somewhat more advanced, but still fairly elementary, comparative evaluation of satellite-distributed television for India and Latin America.

On the other hand, the study reported in Appendix V is much more sophisticated technically. It develops rather precise measures for variables relevant to the engineering of the different types of technology concerned and it uses a computer program which amounts to a simulation to appraise alternative systems. The systems under consideration in these three appendices are not exactly the same. (For instance, the system described in Appendix V provides reverse audio links from students

to teachers in addition to television broadcasts from teachers to students.) But essentially they all compare large scale terrestrial communications systems with celestial systems and hybrid systems.

The engineering effectiveness of satellite communications depends upon the capability of the satellite to transmit signals to an entire area on the surface of the earth or indeed to a three-dimensional spatial region on the surface of the earth and above. In this it differs from terrestrial communications--wires, cables, or microwave links which transmit signals only over specific linear routes along the surface of the earth.[35] Since the expense of a communication link between a satellite and any single earth receiving station is the costs of the transmitting and receiving stations, and these costs differ little with location so long as it is within the "footprint" of the satellite (i.e., the region of the earth covered by it), the costs of the communication link, as well as its engineering effectiveness, are independent of the length of the link. This is a remarkable new fact in communications engineering. Also signals from the satellite can often get around mountains and large structures, cross rivers and seas, and pass beyond the earth's horizon. Broadcast signals cannot do these things, and they may be different and costly for cable, microwire, or microwave channels.

When one considers the unusual capabilities of communications satellites and considers in addition the fact that radio appears to instruct as effectively as television in many situations but costs only a tenth to a twentieth as much per channel, the promise of satellites for educational radio can be recognized.[36] Satellite radio not only would use scarce financial resources of less developing countries at

least four times as effectively as satellite television, but from an engineering point of view radio uses the valuable radio frequency spectrum almost 200 times as efficiently as television. Also the supply of programming talent, which is often short in a less developed country, is used to greater advantage by radio. Since a much larger number of radio channels than television channels can be available by satellite, radio permits much greater instructional flexibility, including options for CAI or CMI, multilingual broadcasting of the same materials simultaneously, and the sharing of a single satellite by numerous regions of a large country or by several countries.

5. Educational Effectiveness

Even though we have outlined above possible procedures for measuring educational efficiency or effectiveness and combining it with engineering efficiency or effectiveness of any instructional technologies involved, such methods have rarely been used either in established or less developed countries. The ordinary procedure for selecting among alternative educational systems has been to take account of some cost measures, perhaps quite sophisticated, and then to combine with them qualitative subjective judgments about the probable effectiveness of each alternative. As a result most cost-effectiveness measures have really quantified only the costs. The following statement, made by Schramm, Coombs, Kahnert, and Lyle, represents the current situation:[37]

"Ideally, we should like to be able to say that a given cost input will produce a given educational output. Comparable measures of educational output at a sophisticated level are not easy to come by. We have had to

rely for the most part on such measures as unit cost per student-hour of teaching or, in cases where a full curriculum is being taught, on cost per student, per annum. In some cases we have been able to relate average percentile gains on a nationally standardized test to a project input, but these are not comparable internationally. We are lacking in precise knowledge of important side effects of projects, such as, for example, the indirect teacher training that comes from watching television lessons intended for a teacher's own pupils. It is necessary to admit with regret, therefore, that we simply do not have available at present the necessary data with which to treat in any very sophisticated way the comparative educational efficiency of the new media in terms of their costs."

Typically neither traditional programs of education or such programs using instructional technology have been evaluated by using pre- and post-tests of any sort. Rough evaluation measures are used, such as following a "cohort" of students who enter primary school in a particular year, determining how many drop out at the end of each year and how many finish the course. Such evaluation assumes that children who complete a certain level of education have roughly similar achievement and that dropouts lose whatever accomplishments they have made. Neither of these assumptions is necessarily justified.

Though there is no clear-cut objective evidence that use of instructional technologies improve educational effectiveness, they have in general been employed for this purpose rather than to cut costs. As Schramm, Coombs, Kahnert, and Lyle say:[38]

"Adding a project in the new media is very unlikely to reduce the present total expenditure for education. Media costs will be added. Class-room teachers are not going to be replaced by television teachers. More students, rather than fewer, are likely to be taught. Total costs are not coming down. If there is to be any economic justification for using the new media, it must be in terms of output or extension. That is, they must do some teaching better or faster; or they must make it possible for the schools to increase enrollments or to offer some new service at lower cost than could otherwise be possible."

Various procedures have been devised for considering costs, on the one hand, as well as engineering and educational effectiveness, on the other. Two good examples are the work of Sovereign in Appendix III and Jamison in Appendix IV. Both of these, however, are more rigorous in calculating costs than in measuring effectiveness.

5.1 Practical considerations in the educational effectiveness of the instructional technologies. A common first reaction to the proposed application of any instructional or communication medium is that it must surely be less effective than face-to-face interactions between two individuals or in a group. Yet there are several factors which can make the medium more effective than direct human interaction. Let us consider a specific communication medium, television, as used for instruction.

When television is introduced into an instructional system to replace certain traditional elements of that system, it can have advantages over previous traditional teaching. Television lessons can be better prepared and can bring better teachers into the average classroom, despite the

tendency of media presentations to be impersonal. To some people, this impersonality seems to be a large obstacle to effectiveness. Also the mass aspects of the media suggest an unfortunate analogy with mass production in assembly-line manufacture. It is often expected, therefore, that students taught by instructional media will achieve poorer results than students who have been taught by traditional methods. If this is so, it has not been detected in a very large number of comparative studies. Neither has any evidence been found to indicate that presentation via an instructional medium per se results in any greater scholastic achievement than classroom presentation.[39] Proponents of instructional television say that the current research literature shows it to be at least as effective as conventional teaching, so it may be used where economies are indicated and feasible without fear of lowering standards. Some skeptics say the failure to show any significant differences between the two modes of teaching may result from the inadequacy of the measuring methods used. Others suggest that it results from the inadequacy of our knowledge about the learning process. Indeed the two instructional modes may be equally inept.

Many of the relevant researches have failed to measure some of the most important factors in learning. In order to be scientifically valid, many were designed to control what seemed to be the chief relevant variables except the main independent variable under examination--television versus face-to-face instruction. In real life however, the introduction of a new significant element such as television into an instructional system affects all other parts of the system, and in these secondary and usually unmeasured effects, instructional media often prove advantageous.

We shall examine several indirect effects which may result from a typical use of television instruction, the initial exposition of a given subject-matter. There are ways in which instructional television lessons can be superior to classroom lessons, and therefore by usual standards be more effective.

1. Instructional television lessons can provide audiovisual enrichment. Audio and visual materials of many kinds may be used in television production in ways which are not easily possible in the classroom. The television teacher can spend much more time than the classroom teacher on the selection and/or production of such materials. He can generally have the assistance of librarians and craftsmen, and also select from a wider range of materials. Thus, the televised lesson can be greatly enhanced in audiovisual complexity. Insofar as this is constructive rather than distracting it can lead to increased effectiveness.

2. More effort can be put into the preparation of instructional television lessons. Since they reach many learners in many classrooms, more time and energy can go into them than is available by the ordinary economics of school instruction. Assuming that this energy is well directed, a lesson presented by instructional television can be better thought out, better organized, and better presented than the usual classroom lesson, and thus quite possibly more effective educationally.

3. Instructional television lessons can raise the average level of lesson quality in a school system. When television is used as a mode of basic presentation, presumably of the highest available quality, it

replaces many good, bad, and mediocre classroom presentations of the same material. Potentially the medium thus can raise the average level of effectiveness of presentation of lessons throughout the system and so facilitate a higher overall level of student achievement.

4. Instructional television is presented more publicly than traditional classroom lessons because it is broadcast or carried over a closed-circuit system to numerous classrooms. Administrators, colleagues, and visitors are likely to see it since it is not confined to the relative privacy of the single classroom. The teacher and others involved in programming and presentation realize this and as a result are motivated to greater care and effort, and hopefully greater effectiveness. This intensity sometimes creates nervousness or camera fright, producing stiffness and formality that diminish the impact of communication. Consequently a teacher who is excellent in the classroom is deadly on television. With proper direction this handicap can usually be overcome, however.

5. The use of television for instruction may release classroom teachers for other important educational, research, or service functions. Many instructional functions traditionally performed by the classrsom teacher may be carried out by television, including lesson presentation, drill, practice, and review. This releases the teacher for what are probably the most important experiences in the classroom, which only a live teacher in a personal relationship can provide: interaction, understanding, encouragement, counseling, informal progress appraisal, and sincere personal interest. The teacher as group leader can aid the student in relating with his peers and becoming a member of a social unit.

All five of the above points concern how television is used. None, except possibly the fourth, is inherent within the medium itself. Because research on television has concentrated on discovering instructional advantages inherent in the medium itself, its indirect effects on other components of the educational system have been somewhat neglected.

If instruction is to be improved by better communication, the improvement will probably come more from what is communicated than from how the message is conveyed. The design of an instructional message plus the way it is integrated and coordinated into the other functions of the use systems will determine the degree of success of the user system far more than the mere choice of medium to be used. Too often program materials in film, television, radio, and other media are evaluated according to criteria which are not relevant to their intended use. Often the criteria are derived from some entirely different system for which the materials were never intended and in which the purposes are altogether different. A prime example of this is the evaluation of instructional films or tapes by the standards of entertainment.

Chu and Schramm conclude:[40] "The research seems to suggest that effective use of television grows out of attention to the basic requirements of good teaching, rather than to any fanciness that might be peculiar to television."

5.2 Practical reasons for ineffectiveness of instructional technologies. Explanations for poor performance in an instructional medium may be found in the technical transmission or recording component, the program display component, and the program production component. These sources of problems are listed in order of ascending importance and will be discussed in that order.

5.2.1 Transmission or recording failures. Inadequate transmission or recording may be caused by equipment failure or faulty human operation resulting in either partial or total loss of signal transmission or imperament of it by noise. The more complex a piece of hardware, the greater is the probability of breakdown in it and the shorter the mean time between failures. The probability of failure increases if less expensive parts and workmanship have been used in making products when low initial cost is a prime factor in sales. Still another factor in failure is the rapid change in hardware from one season to the next because the market may be primarily interested in the newest and the latest, rather than the most reliable equipment. A high rate of obsolescence precludes the perfection of a single model through gradual minor changes, the success secret of the Volkswagon car. Continual design change requires the constant testing out of new models and devices by the customer under conditions of regular use. It is no surprise that equipment reliability has been such a problem in the underdeveloped countries where maintenance and repair facilities are meager. For this reason use of many of the more complex instructional media is not feasible there. Broadcasting systems, especially those which depend on commercial income and to whom downtime means a heavy financial loss, find it necessary to have duplicate equipment ready at all times for immediate replacement. Television film projectors, for instance, have duel lamp housing, automated so that failure of one lamp immediately switches on the other. Synchronizing pulse generators, a key item of equipment for television program origination, are regularly manufactured in pairs with automated changeover in case of failure.

Remote television pick-ups from ballparks, golf courses, and elsewhere are provided with stand-by microwave lengths, stand-by cameras, and stand-by audio transmission lines as insurance against failure.

In the case of recording systems, recording playback, and program display equipment can cause similar technical problems. Distribution by transportation is analogous to transmission by telecommunication media. A loss or delay in the mails, in the messenger system, or by a previous user of materials, who is expected to send them on to the next user, sometimes results from transportation equipment trouble, but most often from human factors. Such breakdowns can be just as serious as transmission failure in telecommunication systems.

Preventive maintenance can reduce unexpected equipment failures by replacing poorly functioning elements before they break down, but only at the cost of additional maintenance hours and added downtime.

Radio static, television "snow," electrical interference, cross-talk, an unwanted program superimposed on one that is wanted, and various other sorts of "noise" can seriously impair instructional effectiveness. Noise in films and slides can derive from excess graininess of image, excess dirt, scratches on film, and various errors in film development or tape recording such as excess contrast which makes it difficult to distinguish details in highlight or shadow areas. Sometimes noise is introduced by equipment malfunctioning, such as hum in audio systems, arcing of switches, and rollovers in television switching. Noise can be prevented only by constant care: careful shielding of equipment from outside radiation, broadcast signals, or static; careful maintenance of equipment to prevent

internal noises; care and cleaning in every stage of the photographic operation; and care in the adjustment and operation of all equipment.

5.2.2 Program display failure. Program display components add further possible additional reasons for ineffective equipment performance. The same hardware and human factors listed above are involved, and they are by the facts that display equipment is often cheaply built to attract a large market and is operated by people of substandard technical competence. In one Maryland county school system which has some 750 television receivers operating in classrooms, maintenance records for one of the early years of operation show that 45 percent of calls to classrooms for repair service were resolved plugging the receiver's power cord back into the wall, from whence the janitor quite possibly had dislodged it during his cleaning the night before.

Projection of audiovisual materials is traditionally plagued by human failures. These include lack of planning and failure to safeguard adequately against accidents. Someone seems to trip over a cord and disconnect a projector at least once every time a film slide project is operated. As often as not one or more slides in a stereopticon will be in the wrong position. At one national convention--of an audiovisual association, of all places--display failures were close to 100 percent. Screens were set up in meeting rooms with large, high windows which could not be curtained. Speakers arrived before the scheduled times of their speeches to arrange slides or movie films and found no projectors provided, or projectors of the wrong sort. When the right projector was on hand, it failed to operate. One speaker substituted for his speech a screaming criticism of this situation. The following year a special coordinator, trained in

the Navy, was assigned to each meeting to plan, double check, and take responsibility for the equipment. The incidence of trouble dropped to an all-time low.

5.2.3 Program production failures. Even though all equipment and operators function flawlessly, media can still perform ineffectively for human reasons. Some failures arise from the planning and production of the programs themselves. For example, program production can introduce what amounts to noise in the message.

Many instructional film or television producers introduce sorts of showmanship into their projection which prevent them from achieving their primary purpose. These may be intended as attention-getting and attention-holding devices, but they are often distracting "gimmicks." In one film for engineers it was decided to have a series of verbally discussed items also displayed in print for additional clarity and emphasis. This film producer had these items printed on cards in too small type. The entire set of cards was held by a model in a bathing suit. She stood facing the camera, the cards at first covering her from neck to knee, then gradually revealing more and more of her lovely anatomy as she removed one card after another. The introduction of distractions that divide or capture the attention of the viewer can diminish effective communication as much as noise which actually obscures the message.

Or the producer may couch his program in a style which is unpleasant to the viewer. A stiff and formal lecturer may be emotionally rejected by the viewer. He becomes bored. His mind wanders. Looking for distraction, he may fasten his attention on the speaker's idiocracies or on the background. Eventually the message is lost.

The producer may fail simply because he has structured his program poorly. If a presentation is not developed logically, points may be lost because prerequisite ideas were not presented first. This is a failure of the message design. A common fault is the combining of visual materials with spoken words. Used properly, visuals may enhance words, and words may define and clarify visuals. Used badly, these two channels of information can fight one another, blocking perception of either or both.

Poor judgments may make pace of the program wrong. If it is paced too fast and the ideas crowd in upon the viewer faster than he can assimilate them or write them down in his notebook for later study, they will be lost. If a program is paced too slow so that ideas do not come fast enough to hold the viewer's interest and attention, he may not be reached at all.

There are, thus, many practical aspects to the use of instructional technology in the most effective way. Efforts must be made to consider all these factors if the educational system is to achieve its purposes optimally. The impact of each must be evaluated in measuring educational effectiveness.

6. Conclusion

The conclusion, then, is that methods are slowly being developed to measure educational effectiveness. One day these will become a science, though that day may be years away. We have outlined above ideal procedures for such evaluation. In a few studies reported in the literature, like the evaluation of educational television in El Salvador, these methods have begun to be applied.[41] No single example of such evaluation conducted in a controlled way, employing both formative and summative evaluation, can

yet be pointed to. Yet such procedures urgently need to be applied to provide a technical basis for selecting among alternative educational systems for less developed countries. Unless they are applied, such decisions will be made on the basis of cost measures alone, rather than on a basis of rigorous cost-effectiveness estimates. Even though true cost-effectiveness evaluation has yet to be applied in the selection among alternative educational systems, it is as likely to be used first in one of the less developed countries as in the United States. This is because there is widespread resistance by traditional educators in the United States (and in other established countries) to the use of new instructional methods, and to evaluation by others or even to self-evaluation.

CHAPTER V

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CHAPTER VI

THE FINAL CHOICE AMONG ALTERNATIVE SYSTEMS

When all the alternatives for a large-scale educational system have been stated and examined; when their various sorts of costs have been estimated; when the engineering effectiveness of any technology used in each alternative has been calculated and its probable overall educational effectiveness determined, a technical recommendation about the final choice among systems can be made. (The appendices to this document contain illustrations of various technical approaches to selections among alternative systems.) The optimal system technically, however, is not necessarily the alternative that should be implemented. The ultimate decision usually is--and should be--political and practical rather than technical. It is better made if all the relevant technical considerations have been reviewed in as precise and quantitative a way as possible. It is better made in the light of a careful cost-effectiveness evaluation of each feasible alternative rather than in ignorance of such considerations. But finally the governmental authorities must decide in terms of all aspects of the society to be served by the proposed educational system. To imbed it in that society most permanently and successfully, they must take many political and practical considerations into account. The purpose of this chapter is to analyze the range of such considerations which enter into the ultimate decision which is the duty of the political officials to make.

This chapter will deal first with one of the most complicated aspects of a society, its channel and net or communications subsystem. The complexities of such subsystems in less developed countries will be considered. Then we shall review key policy issues related to their use. Social development programs which employ communications will be defined, and then the applications of communications systems to social development programs will be studied. After that major areas of practical educational problems in less developed countries will be reviewed, including political, economic and planning, social and cultural, technical and social development issues. Finally, some approaches to solutions of these problems will be discussed.

1. Communications in Less Developed Countries

1.1 Technical and organizational complexity. National communications systems are always complex. They involve not only the operational system itself with facilities for programming, transmission, and reception, but also units for planning, procurement, and installation and maintenance of equipment. In conceptualizing and planning a communications system it is necessary to coordinate the persons who specify the original requirements, the planners, the implementers, and those who are actually going to use the system. These often come from a wide variety of organizational units and are difficult to identify when no operational system exists.

Educational and other social development programs are usually not the primary justifications for developing a national communications system. The usual public and private telecommunications needs of a country,

including military and other governmental requirements, are usually the primary motivating factors. All telecommunications media may be employed, including telephone, radio, television, facsimile transmission and data communications.

1.2 Multidepartmental involvement. In the national governments of most countries numerous departments or ministries are responsible for social development programs. They include, typically, Departments of Education, Agriculture, Manpower Development, Social Welfare, Health, Public Information, and Culture, to name only a few. Implementation responsibilities often are lodged in a Department of Communications. Intragovernmental relations often are coordinated by a Department of the Interior, and external affairs by a Department of State or Foreign Affairs. These departments normally are moderately autonomous in their operations, with their own staff and budgets. Getting them to collaborate in considering any major new project is often difficult. Commonly a key question is who has responsibility for initiating such cooperation.

Many social development activities, such as functional literacy or integrated rural development, often are not the responsibilities of any single department but are spread between many departments. Obviously it is hard to initiate and coordinate efforts involving so many organizations.

1.3 Requirements for change. A communications system is too costly normally to be afforded by a developing country merely as a supplement to existing programs. Instead, because it offers greatly increased capability, if it is to justify its cost it must be used to improve major

national activities or make possible large-scale extensions of current programs. Innovation is required in planning such utilization, not just expanded operations in a traditional mode. Thus major changes in programming, operation, and organization of each of the departments involved are essential if truly effective use of the capabilities of the new communications media is to be achieved. These create all the problems that massive change always brings--threats to established organizational structures, alterations in budgetary allocations, and the need to rethink basic objectives, policies, and strategies in each social development program area concerned.

1.4 Major cost commitment. The choice of a communications system is a major cost commitment which requires analysis by major governmental officials of a developing country. Coordinating their efforts and obtaining the necessary time from their busy schedules obviously may delay and complicate decisions on any type of communications system under consideration.

1.5 Policy questions and challenges. It is not less easy for a developed country to decide to use a particular communications system. In selecting it they must face up to serious policy questions which go to the heart of governmental strategy and operation. They also involve major long-term national commitments on such key policy issues as we shall discuss below.

1.6 Difficulties in measuring program cost-benefits and justifying new programs. The results of social development programs are hard to

measure. Consequently it is hard to justify changes in established ways of carrying them out--new innovative approaches to them. Economist who ask question about the cost-benefits of such systems are generally dissatisfied with the precision of the answers which can be achieved. Thus justifying a high cost--often many millions of dollars--for a communication system for social development is most difficult.

1.7 Long-term commitment requirements. The selection of any communications system requires a commitment over a long time period spanning many budget years. Officials are often reluctant to establish commitments for many years when so many short-range problems beset the budget planners. Since the largest costs usually must be met in the second or third year after the initial decision is made (because the earliest commitments are for relatively cheap planning and recruitment functions and it is not until the second or third year that large budgetary provisions must be made for equipment, construction, and operations) official reluctance increases. Budgeters are usually less willing to make major commitments several years ahead than in the current or next year when what resources are available is better known.

2. Key Policy Issues

Selection of a communications system, of whatever type, by a less developed country requires that prior decisions be made on a number of key policy issues. They fall into four general categories:

- National goals and objectives
- Degree of centralization of control
- Complications of international commitments
- Planning policy questions

Analysis and understanding of each of these ares is necessary.

2.1 National goals and objectives. Less developed countries are increasingly accepting centralized national planning as a necessity, creating overall long-range development plans. Establishing objectives for economic development, such as a given percentage increase in agricultural productivity, however, is far easier than setting objectives in the social development field. Further, while drafting such objectives is one thing, obtaining acceptance and consensus about them is often a far different thing when bodies other than the central government are involved. Yet the establishment of such national objectives is absolutely essential to the planning of a major national communications system, for it is on the basis of its ability to fulfill these objectives that justifications can be made for whatever type of system is selected. Many areas of national concern listed below are expressed implicitly rather than explicitly in the formulation of these objectives, yet they must be considered if a good job of planning is to be done. Rather than listing a series of typical objectives here, it will probably be more useful to mention the areas of objectives which must be considered.

2.1.1 National Integration. The need for national unity is often one of the most compelling issues in a less developed country. Divided

by historic rivalries, by geographic boundaries, and by social, ethnic and political divisions, a national government needs to weld a strong, supportive constituency among its citizens if it is to survive and be effective. A national communications system, capable of reaching all the citizenry, is vital if this objective is to be achieved. This potential of a communications network can well be the most telling justification for it.

2.1.2 Priority of social development. Traditionally over the past decade economic development projects have had top priority. New dams, highways, port and harbor facilities, airports, or industrial plants have always led the list. Even programs for increasing agricultural productivity usually give top priority to construction of new fertilizer plants, importation of pesticides, or design of new irrigation systems. The limited success of such programs has produced a realization that they cannot be achieved without adequate human resources. Consequently higher priorities are now being assigned to education, health, or manpower development. These higher priorities in turn justify the establishment of communications systems which serve social development programs.

2.1.3 National prestige and modernity. Such objectives are stated implicitly much more often than explicitly, yet they are frequently at the heart of some of the most significant national decisions. The desire of a less developed country is strong to appear to the rest of the world as stable, of high prestige, and "modern". A satellite communica-

tions system, for example, is the ultimate in modernity. Often the desire to appear up-to-date is the chief basis for decisions, which turn out to be totally inappropriate for the country's real requirements. Attempts to justify rationally less costly and less sophisticated systems may run into insurmountable roadblocks which result from the desire for the most modern and sophisticated approach possible in order to build national prestige. Selection of a highly sophisticated system may be the worst possible decision if it is not really needed or if the country does not have the local financial, economic, and social resources to support it.

2.1.4 Quality and quantity. The two horns of the dilemma of quality and quantity often constitute serious problems for less developed countries. Normally the justification for installing some innovation such as a national communications system, is based primarily upon the need for increase of both these elements within the society, yet often there must be trade-offs between them which are extremely difficult to state and evaluate. [1]

Often the quality of social development programs, particularly education, is inadequate. The potential of a communications system to distribute the best programming or teaching capability in the country throughout the country, is an extremely strong argument for it. Increased quality, however, usually costs more and it is difficult to evaluate the differential between present quality and that available by the network. The most significant contribution a communications

system can make is one of the most difficult to measure and, therefore, justify.

As to the issue of quantity, many social development programs fail in less developed countries because they do not reach any significant portion of the population. As Coombs has aptly said: [2]

> "Many government agencies have programs specifically aimed at the villages, but due to many circumstances they run out of steam before they actually reach the village level and thus are minimally effective with the target population they were designed to reach."

A national communications system if properly exploited, can bring education to a large population. Since it is expensive, its cost must be justified by the increase in the number of people that are educated. Fortunately, such quantitative changes are relatively easy to measure and therefore justification based on them is much more straight-forward.

One major problem in setting national goals and objectives is the unwillingness of many who are currently in charge of programs to admit the shortcomings of their programs in order to make it possible to determine what improvements need to be achieved. In one less developed country, for example, although the records of the central government showed that there was a social development unit in almost every village, less than 10 per cent of those units were actually organized and functioning. The others existed only on paper. Obviously the quantitative improvment due to a communications system could be major, but proof of its necessity was difficult to achieve.

2.2 Degree of centralization of control. The question as to who

has overall control of both the operation and the programming of the communication system can be an extremely thorny issue. It would appear by definition that the central government must have a leading role in planning and implementating a "national" system, yet the responsibility--particularly for programming and using the system--often is, for political or social reasons, delegated to provincial or local levels. A prime example of this is the proposed India satellite system.[3] The numerous native languages of India as well as the autonomy of the individual states require that programming responsibilities be delegated to the provincial level. This is not easy in a staellite-based system which covers a large country with a limited number of channels and of broadcast hours. Political consideration, however, may dictate decentralized control of education and this must be included in the design specifications of the communications system.

It is often possible to resolve questions of control by intelligent compromises which will maximize the planning and programming of the system while meeting provincial and local demands for participation in programming and operational responsibilities. This often requires a high degree of bureaucratic cooperation, but this can be achieved to the great benefit of the entire program if intelligently and rationally approached.

2.3 Complications of international commitments. Probably no less developed country can plan and implement a national communications system using only its own internal resources. Thus it is necessary to depend

on international commitments, to a greater or lesser degree. Ranging from the necessarily great foreign involvement in a satellite system to the relatively simple involvement if audiovisual materials only are required, these international commitments may require difficult policy decisions. This section deals primarily with the commitments required. In later sections we shall deal with other related issues.

2.3.1 Satellite systems. Satellite systems involve major international commitments by the less developed country to the nation which launches, supplies, and maintains the satellite, and replaces it when its life is over. There are also international problems of software copyright and frequency spectrum coordination.

2.3.2 Suppliers. To obtain technical assistance, equipment and perhaps software, a less developed country must participate in international transactions. Many suppliers of communications systems constantly try to sell their own particular hardware or software to less developed countries. The decisions as to whether to import such necessities or to develop a local industry are intricate. A well planned social development program can create many jobs and a great deal of local industrial development if properly planned. These can decrease the need for imports from abroad. Such planning, however, requires coordination among ministries or departments, good scheduling, and strategies to overcome local constraints. Some commitments with foreign suppliers or foreign sources of capital and expertise to promote

the development of local industry are usually necessary.

2.3.3 Software. With the increasing usage of communications systems for education and other social development programs, larger amounts of software are being made available. Some of this is excellent, applicable to the needs of less developed countries. Programming is expensive, so whenever available software can be utilized, either directly or by translating it to the proper language and adapting it to the culture, it can often be of great value to a less developed country. The identification, evaluation and modification to the local situation of the software is difficult, however. Obtaining copyright permission may also involve complications.

2.3.4 Joint usage and conflicts. Many developing nations are too small to use a communications satellite effectively by themselves. In such cases joint international use is possible. Major land-based communications systems may also be used internationally. Such cooperation requires international commitments about objectives, priorities, utilization ratios, financing, and scheduling. Antagonisms between neighboring countries may complicate such cooperation, or in some cases make it totally impossible.

2.3.5 Funding sources. Few developing countries are able to finance a total national electronic communication system completely out of their own resources. Therefore they must look abroad for sources of funding, for bilateral assistance, multilateral grants or loans, or arrangements made with private organizations in foreign countries.

Sometimes the availability of financing from one particular source may swing the decision to a particular sort of communications system, because the funding carries with it a certain degree of pressure to that type of system or at least to a particular source of hardware. The specific financing terms can also be crucial in selecting the type of system, even though the kind chosen may not be the best to meet the overall requirements.

2.4 Planning policy questions. Decisions involving implementation of communications systems require facing a number of key issues such as:

- The time frame for planning
- Real time versus non real-time requirements
- Technological forecasting
- Required population coverage
- Rate of development
- Degree of required experimentation
- Urbanization pressures
- Interrelationships of communication and transportation systems
- High-technology versus labor-intensive approaches

Each of these planning policies involves inter-related decisions which can vitally affect the overall communications systems planning.

2.4.1 The time frame for planning. The decision as to what time frame is to be used, be it one, five, ten, or twenty years into the future, is of vital significance in the planning of communications systems. A key issue is whether the adjustments that must be made to

meet the urgency of immediate requirements overshadow the long-term benefits to be obtained from a communications system.

Many less developed countries operate on a one-year budgeting cycle and a five-year planning cycle. Some capital development projects, such as national communications systems, however, require a planning time frame of between ten and twenty years if their maximal benefits are to be achieved. Several years are required before their economic impact can be assessed. Many countries are firmly committed to the value of investment in primary education, but this belief can only be justified economically after an analysis over a time frame extending between ten and twenty years, the time it takes for graduates of primary education to enter and become effective in the labor force. Thus the choice of planning time frame is extremely important in evaluating the impact of education which makes use of any communications system.

2.4.2 Real-time vs. non real-time requirements. In planning communications systems a central question is how immediate must be the transmission of the information. At one extreme, a speech by the country's chief executive carried live on either radio or television immediately to the populace is commonly considered vital in promoting and maintaining national integration. At the other extreme, many educational course materials which could be communicated in training programs could be prepared a year or more in advance. Between these extremes lies a whole range of other information services of intermediate urgency. Agricultural development programming, for example, may include

discussions relevant to current weather conditions which vary from day to day. Health programs may include packaged materials reusable many times and also information on specific epidemics which might require daily or hourly updating.

Immediacy of information transmission costs money. Thus the planning of communications systems requirements should take into account the degree of immediacy necessary for each use of the communications system and the alternatives for achieving it. If, for example, no requirements exist that exceed the ability of the country's transportation or mail systems to deliver packaged material from the originator to the user, then a nonelectronic transmission medium may be entirely adequate. The importance of such analyses cannot be overemphasized. In one study the assumption was made that the services of electronic communication can be equaled only by daily delivery of recorded materials to receiving or distribution points.[4] This assumption meant that the cost of this manual distribution procedure was high. If it were adequate to deliver materials on a monthly or even quarterly basis, distribution costs would be greatly reduced and cost comparisons of transportation and electronic communication systems would be much more favorable to the former.

2.4.3 Technological forcasting. Costs of satellite communications, may change by an order of magnitude over a decade, as a result of new technological developments. Consequently both technological and cost forecasting are extremely difficult. This is true for all the electronic media. Cost comparisons valid under one set of technological assumptions

may be completely reversed by new technological developments. While these shifting factors create great problems for planners, they must be taken into account.

2.4.4 Required population coverage. Coverage of a small portion of a population by an electronic communication system can often be easily accomplished by concentrating on urban areas. Up to 80 or 90 per cent of the population, even in a predominantly agricultural country, may be serviced by terrestrial broadcasting stations and standard receivers. However, population coverage of 100 per cent may require expenditure of a great deal more money, to service sparsely populated areas, ones difficult of access by either transportation or communications and ones which do not have electric power. Thus costs are strongly influenced by the population percentage to be serviced. This factor must be carefully considered in choosing the type of communications system.

2.4.5 Rate of development. Both the planned and the actual rate of national development can influence planning for a national communications system. In a slowly growing economy, slow expansion of existing systems of communications and transportation may be the appropriate thing to do, whereas in a rapidly developing economy major changes may be required to achieve the optimal solution for serving the country. In making such decisions it is well to remember that communications can both serve and accelerate national development.

2.4.6 Degree of required experimentation. How much research should planners carry out to obtain data necessary to assure that their final

systems recommendations are as valid as possible? Such experimentation may involve the technical aspects of communications system operations, the programming of the software or courseware to be transmitted by the communications system, the effectiveness of this courseware, and organizational aspects of the final system implementation. A cautious approach to such research could require a large monetary outlay and delay eventual system implementation by months or years. Since system costs generally rise over time because of inflation and other factors, any lengthy delay could increase total system costs markedly as well as deprive the country for a time of the educational and other benefits which could be derived. On the other hand, too hasty selection of a system may well involve premature commitments to elements which may later prove to be inadequate or inappropriate. It is important to calculate correctly the trade-offs between the gains from planning-oriented research and the losses from delay.

2.4.7 Urbanization pressures. In many less developed as well as established countries there is a rapid rate of population movement from rural to urban areas because of the better job opportunities and apparently higher quality of life generally in cities. If, in addition, communications systems decisions favor urban areas by providing them with more or better services than rural areas, the flight to the cities may be accelerated. If for example, television becomes available in the cities but only radio can be received in the rural areas, urbanization may speed up enough to create economic losses exceeding the cost of providing television coverage in rural areas, or justifying a decision not to begin

television until it could be provided in both rural and urban areas. A total national system analysis of the optimal location of transmitting facilities and their potential impacts is crucially important.

2.4.8 Interrelationships of communication and transportation systems. Some communications planners would like to evolve their system designs without regard to other subsystems of the society. If this were done, however, they would be incomplete and faulty. Every national communication system for instance, is integrally interrelated to its transportation system for human beings, equipment, electric and other energy, and the mails. In planning any network for communications, provision must be made for transporting construction materials and equipment to selected sites and subsequently for transporting personnel, materials, and parts for operation and maintenance of the system eventually implemented.

Most educational and other social development are more effective if supported locally by trained personnel and ancillary materials such as texts or audiovisual aids. A trained discussion leader, for instance, can follow up on agricultural broadcast information with local discussions with farmers and action groups following programs outlined in workbooks. Supplemental work sheets, testing materials, and related charts and pictures can heighten the impact of educational broadcasting, by either radio or television. In addition, trained personnel are needed to operate the communication system and related local training and feedback activities. In simplest form the transportation for the ancillary

materials could be the mail system. Or it might be by a transportation system set up for the particular purpose, conveying, on a regularly scheduled basis, substantial amounts of supplemental materials. Both the cost and scheduling of such transportation of support personnel and ancillary materials must be considered in planning any communication system.

The fact that local support personnel and supplemental materials may be required is a significant consideration in the evaluation of the relative merits and costs of electronic versus manual distribution systems. It may be possible to achieve cost savings by distributing both the principal program materials in recorded form and the supplemental materials by the same transportation or communication network. Unfortunately this entire question of supplemental personnel and supplemental materials is often ignored in the costing of electronic systems so that the total costs are significantly underestimated.

2.4.9 High technology versus labor intensive approaches. One of the easiest solutions for planners of communication systems for less developed countries is to import high technology from established countries. But this may not be the best solution. It may be much harder to implement a more cost-effective solution—the creation of labor-intensive low or medium technology approaches which could more effectively use the labor force in the less developed country. The labor forces in many such countries are underutilized. For income distribution to be more equitable, more priority in national planning needs to be given

to labor-intensive approaches to education and other social development activities. Often the highest technology, most sophisticated, and "most modern" communications methods are not the best for a country with a large labor surplus.

A plan to use a modern communication satellite for education, for example, would involve the most advanced technology and the fewest large-scale terrestrial installations. By contrast, a ground transportation system to convey textbooks and audiovisual aids to teachers in traditional classrooms would involve many more people, and would be more labor-intensive. A key question which planners must answer is what weight should be given to a national objective of increasing employment. If its priority is high enough, it may override any calculations which indicate that a capital-intensive, high-technology approach would be more cost-effective than a labor-intensive, low-technology approach. Or, if a less developed country cannot mobilize enough capital to obtain the equipment and technical aid needed for the high-technology approach, it may be forced to reject it even though it would clearly be more cost-effective.

3. Social Development Programs

It is appropriate at this point to consider the types of social development programs which could effectively use the services of a national communication system. The qualification "national" provides certain

guidelines for this list. The programs will be countrywide, not local, and commonly one or more agencies of the national government. Several--perhaps all--of the subsystems of the society will be served. For each type of program a brief description is also given of some of the ways in which a communication system might further its aims.

3.1 Formal education. Instructional technologies employing communications can be used in educational institutions from prekindergarten to university post-graduate courses. Substantively it could include actual classroom instruction materials, teacher guidance for classroom instruction, teacher training, both pre-service and in-service, and training of administrators as well as local, provincial and national government officials. It could even include material covering organization of local school boards or citizen supportive groups for the schools.

3.2 Nonformal education. Most education does not occur in schools and colleges. They make up only a minor part of a nation's associator subsystem . The potential of communications in nonformal education programs, as an alternative or supplement to schools, is only beginning to be realized by many educators, planners, and government policy makers. As more and more countries recognize the difficulty and probable futility of trying to improve their formal school systems to provide the quality of education which they desire for the entire populace, more and more emphasis is likely to be placed on nonformal education.[5] In this communications and information processing technology can play a vital role. Individual home reception or listener groups, perhaps

integrated with part-time school activities and using supplemental printed texts or programmed learning materials, are possible formats. The "Open University" experiments underway or contemplated in several countries are good examples of the integration of a number of different media and modes of presentation for nonformal education.

3.3 Manpower development. In preparing men and women for employment, communications can be used in many fields, including vocational training, management development, employment readiness, and motivational training.

3.4 Population control and family planning. Communications can serve both informational and motivational purposes, for the general population as well as community workers involved in population and family planning programs.[6] This is a chief emphasis of the Indian satellite experiment and the results should be useful for evaluating other potential programs. Now that methods have been developed for calculating cost-benefits of population control programs, it may well be that the prime justification for instructional communication systems will be made on this basis, other social development programs being secondary.[7] Certainly a national communication system offers one of the most effective ways of reaching widely dispersed, illiterate populations cheaply and rapidly to control population growth.

3.5 Agricultural and rural development. Communications have been used for many years to promote increased agricultural productivity by improving farming practices. Examples abound, such as the radio forum in India or the Colombian national radio.

3.5.1 Agriculture. In the agricultural area communications systems can improve agricultural productivity through training (a) in the use of new seeds, fertilizers, pesticides, and other practices, and (b) in the marketing and distribution of farm products.

3.5.2 Rural development. In the evolving field of integrated rural development there are many areas in which communications can contribute, including initiation of agriculturally oriented industry and development of relationships with other fields such as improved health, community development, and education. Trying to stabilize the rural population, improve its standard of living, and reduce or minimize the migration to the cities are objective of most less developed countries, objectives that most are not yet able to handle. A few governments are starting to institute units concerned with integrated rural development, but they so far are in the minority. Even the international development agencies are only beginning to recognize the necessity of taking an integrated systems approach to the problems of rural development.

3.6 Community development. Closely related functionally to rural development, but usually separately organized in most developing countries' governmental structures, community development programs can be enhanced immeasurably by communications for both informational and motivational needs. Closer integration of the community development workers in various specialties can be achieved through electronic communications, appropriate administrative structures and distribution of supplemental materials.

3.7 Urban development. Communications are used somewhat erratically

for urban development as a planned governmental policy in most less developed countries, primarily because of the difficulty of working out integrated urban development policies. As a means of informing rural area residents about poor living conditions and lack of opportunities in the cities, a communication system can be used effectively to slow down urban migration. Also to provide information regarding rules and regulations, employment opportunities, and other elements of the urban administration, it can be a most useful medium.

3.8 National integration. A national communication system can play a most important role in promoting national integration. It can enhance overall political unity, promote use of the national language, and reinforce national social and cultural values. In national political activities or during national crises, arising either from national or regional disasters or political uprisings, immediacy of access to most or all of the population is desirable.

3.9 Functional literacy. Although literacy simply to be able to read and write is currently out of vogue, even in countries with high incidences of illiteracy, several successful functional literacy programs exist that combine improvement in work with literacy development which makes effective use of communications systems.[8]

3.10 Health and hygiene. National communications systems can be effectively utilized both for improvement of health practices as well as in national disease and epidemic prevention and control. Liaison among health workers throughout the country can be accomplished more

effectively through national communications than through administrative channels.

3.11 Nutrition. With increasing recognition of the need for balanced nutrition to produce normal mental and physical development, increasing emphasis is being placed in many countries on food production, distribution, and consumption. Nutritional practices, individually and collectively, can certainly be significantly improved by use of national communication systems.

3.12 Public information and entertainment. Communication of public information, often handled by a Department or Ministry of Information, serves to integrate a nation as well as further general development of a literate and informed population. Entertainment, considered by some as extragovernmental or unnecessary, can provide the essential leavening that makes all social development programming more effective and attractive to the general population. It is important in social development and needs to be considered in communications system planning. Regional or local control of some public information and entertainment programming helps to increase listener acceptability.

3.13 Cultural improvement and preservation. Although this social development function almost invariably comes at the end of a list such as this, it is important to preserve the general fabric of a country's culture, as well as promote those cultural features which attract tourism, and increasingly significant industry in many countries. Certainly national communication systems which can distribute cultural

programs and provide an incentive and opportunity for cultural artists to perform, can significantly influence cultural education. Regional and local programming can greatly enrich a nation's cultural development program.

4. Major Problem Areas Related to Education Systems for Social Development

What are the major problem areas encountered in conceptualizing, planning, implementing, and using a communications system for education related to social development in less developed countries? We shall now consider successively those problems that concern politics, economics and planning, social and cultural matters, technical issues, social development programs, and finally implementation and utilization of the system.

4.1 Political Problems. No list of political problems could be completely comprehensive or encompass all the political problems which might arise in the decider subsystem of any given nation. Certain problems which are probably encountered more often than not in the initial planning for a national communications system may be well worth noting in order to understand better some of the political complexities involved in communications system decision making.

4.1.1 Competition for control. A national communications system is a big enterprise, and control of such a system constitutes power in any nation, less developed or established. Thus there is often intensive

competition and rivalry for control of the system. This competitiion may exist at all levels, from international agencies that are interested in having a major part in advising the government on the type, size, and use of the system, through agencies of the national government among which the rivalry is usually the most intense, to provincial and local governments whose capabilities of controlling their areas are affected by their mode of participation in the national communication system. Departments or ministries of education, information, telecommunications and agriculture often vie for control. These rivalries are sometimes compromised by assigning one governmental agency responsiblity for planning and implementing the system and another regulating its use. Often its use is shared by a number of different agencies. The division of responsibility usually results in inefficiencies and continued dissensions as competition for scarce communications channels and transmission time takes place, particularly after the effectiveness of communications has been demonstrated following the system installation. Even planning issues must be approached most delicately to avoid confrontations because the missions of the departments are not clearly defined to prevent overlaps. Obviously it takes strong leadership to resolve these differences and make rational judgments which will work to the overall benefit of all concerned.

4.1.2 Interdepartmental coordination. When eight or ten independent departments of comparable status are competing for channels, time and programming facilities, their coordination may require the establishment of a supradepartmental level coordinating committee, board, or body.

Often such a superordinate national planning agency is set up, but it may not be granted enough authority or manned with sufficient personnel or expertise to fulfill the function efficiently, so nothing can be accomplished because all the involved departments are at the same level in the governmental hierarchy.

One of the greatest mistakes that can be made in attempting to resolve competing demands of several departments is to allot the scarce resources of channels and transmission time on the communication network to so many agencies that each one can use it only to supplement its regular activities rather than to carry out significant parts of its tasks so that costs can be cut. Thus the system ends up costing a great deal more money without replacing less efficient services it could have replaced had more time, programming facilities, and channels been available. It often takes exceptional foresight to design a system with sufficient capacity to serve educational and other social development needs effectively from the outset and thus really achieve some of the potential savings which can be achieved by a major change in the approach to each program.

4.1.3 Short-term development pressures. In most developing countries, the problems vastly outrun the available resources. Thus there is an ever-present tendency to concentrate on those short-term problems which must require immediate solutions. The feeling of "being in a house on fire" often prevails in government agencies whose daily concerns are to solve the most pressing crises which they face. It

takes real governmental organization and forethought to plan ahead sufficiently to face some of the long-term problems with their proper priorities. It is all too easy to adopt a philosphy of "Let's patch up the existing system" rather than undertake really major evolutionary or revolutionary strategies that will make services much more cost-effective once they are implemented.

One way to accomplish this is to assign certain personnel in the planning agencies at all levels to be concerned with long-term solutions and plans, and then require that they PERT those plans, once approved, scheduling a series of required actions from the current moment on until a reasonable date for implementating the plans. Thus the long-term and short-term activities can be identified and implemented each year. This is more likely to result in progress than just hoping that the long-term plans will come to pass.

4.1.4 Politicalization of communicacions. A communication system is a powerful political tool. The national government can use it to further its interests. Some citizens, however, may believe that it furthers these interests at the expense of the people. The possibility that the communication system or segments of it may be used to further the interests of the opposition political party, of student groups working for radical change, or even of revolutionaries who are trying to take over the government is an ever-present threat to the integrity of the national government. Consequently maintaining the security of such a system as well as establishing rules for its operation may become major political

issues. Obviously, providing for all the nations citizens unrestrictive and inexpensive access to all services provided by the network is the most democratic approach, yet this is hard to achieve in politically unstable countries.

4.1.5 Governmental apprehensions. Many apprehensions of governmental officials, either stated or unstated, govern decisions on implementating a national communication system for education and other purposes. Its sociopolitical impact on the populace is hard to predict. Possibly rising aspirations resulting from improved communications may increase pressures from the citizenry for faster economic and social development. The vulnerability of communications facilities to takeover by antigovernment groups, mentioned above, is another major apprehension. Apprehensions may grow out of local socioeconomic conditions. The costs of such a system, for example, may cause taxpayers to resent or actually refuse to pay any added taxes necessary to support such a system and its associated activities. Each of these apprehensions must be recognized and dealt with by the body responsible for implementing the communications system, and considered whenever possible in the systems design.

4.1.6 Nationalism. Nationalism plays a large part in decisions about communications systems. It ranges from resentment of foreign assistance reflected in the attitude of "We want to do it ourselves" to fear of foreign domination in the curricular or other programming material to be used, by various forms of cultural imperialism, or by propaganda or pornography. There is often concern that every stage in

the creation of educational and other social development communications be done by local nationals. Unfortunately this means they must be free to make their own mistakes, which can often be costly in both time and money. There are frequently pressures to give priority to the creation of a local industry in lieu of importing foreign expertise. Also nationalist pressures for ultramodernity often result in choices of systems which are inappropriate, or too expensive or sophisticated for actual needs.

4.1.7 Lack of comprehension by government officials of the system's purposes. One factor too little recognized by foreign experts attempting to assist developing nations is that otherwise well informed government officials often do not comprehend the basic characteristics of communications systems for educational and other purposes. Some of these officials are reluctant to admit that they do not understand the principles involved, but because of this ignorance they refuse to get involved with or make decisions about the system. It is desirable for experts carefully, simply, and diplomatically to assist the officials of the developing nation in achieving the necessary comprehension of these new technologies which is essential for the effective performance of their jobs. Often language plays a more important role than is realized, because even between nominally English-speaking peoples there are wide differences in usages, terminologies, and meanings. Thus care must be taken that words, especially technical ones, be rigorously defined. This becomes increasingly difficult when two or more languages must be spoken among the planners and officials.

4.1.8 Outside pressures. Influences from numerous sources impinge upon the officials of a developing nation. They are frequently too influential in final decisions about the system, and they take many forms.

Suppliers. Commerical salesmen often apply persistent pressures. Unhappily they are too commonly more interested in selling their own hardware or software than in helping the less developed country to which they hope to sell it. They have resources to create attractive sounding proposals, extolling the virtues of their particular offerings but do little to assist the less developed country in evaluating alternative courses of action or alternative types of equipment or materials. Inasmuch as they are commercially motivated, they are usually both insistent and well capitalized, so that their particular presentations are hard to evaluate objectively. Selling electronic communications systems with much imported hardware can be lucrative potential sales as well as attractive to the suppliers of a number of different countries, so hardware sales pressure, possibly from suppliers in several countries, can become intense in nations where the feasibility of a regional or national communciations system becomes apparent.

International Agencies. Although international agencies assisting less developed countries are not supposed to be competitive, in reality conflicting influences may be exerted by personnel from various international agencies in particular directions favored by those agencies. For example, personnel from the FAO may encourage the establishment of a national radio network to promote agricultural

education and rural farm forum broadcasters. The advisors from WHO (the World Health Organization) may well feel the need for national communications to provide health and hygiene nonformal education, while UNESCO advisors propose a television network for formal primary and secondary education. These are often couched in terms which are mutually exclusive or which differ so greatly that consternation develops among officials of the less developed country trying to workout an integrated approach to communications, education and social development. Even officials from the International Telecommunications Union (ITU), supposedly concerned with communications systems, may serve more to confuse than to help. They are often more concerned with frequency allocations and similar technicalities rather than the more basic and difficult problems of merging conflicting use requirements of proposed communications functions for the maximum good of the less developed country.

Bilateral agencies. Many such organizations, like the Export-Import Bank of the United States, try to promote the sale of their own country's products. They find the communications field to be particularly attractive. Thus there is considerable competition among bilateral agencies representing some of the major established countries, such as the United States, Germany, Great Britain, and Japan, to provide the technical assistance which leads up to the design and specification of the communications system. Consequently the less developed country finds it hard to decide how to select its advisors in trying to arrive at an objective system design which optimally meets their requirements.

Local entrepreneurs. Sometimes retired government officials in a less developed country, often backed by foreign firms or money, attempt to achieve decisions favorable to their particular self-interests. This may not necessarily be in the best interest of the country. These pressures are especially hard to resist because they come from within the system of the less developed nation, rather than from outside.

4.1.9 Magnitude of decisions. To begin the creation of a national communications system requires decisions that are larger in scale and more complex in ramifications than almost any other decisions government officials must make. In other major decisions--e.g., about building airports or roads, or about major industrial developments--the points at issue are made identifiable and less pervasive and therefore somewhat easier to make. Both the complexity and the overall cost of a national communications system, on the other hand, are so great that definitive action on it is often delayed.

4.1.10 Organizational constraints. Many shortages and organizational constraints within a less developed country create problems. Among these are:

Internal communications. For a person from an established country, the communications activities of a less developed country are frequently absolutely inconceiveable. They are hampered by poorly functioning telephone systems, inadequate duplicating facilities, and insufficient distribution of simple things like mimeograph machines and pencils. Couriers may have to be relied on to carry handwritten messages. As a

result decisions which require only days in an established country may take weeks or months in a less developed country.

Lack of orientation to messages on paper. In some cultures paper is not widely accepted as a medium for carrying information, and even less for causing something to happen. Receipt of a letter requiring action or response often makes the recipient uncomfortable, and this discomfort may be alleviated by hiding or disposing of the letter. Such behavior is difficult for persons from other cultures to understand, but it may be a significant factor in the poor communications of some less developed countries.

Bureaucratic pathology. Sometimes a less developed country's bureaucracy has been inherited from a former colonial administration. Consequently it may be inadequate to meet the country's current needs, since it was originally set up primarily to serve the needs of the colonial power which ruled it. Both the organizational structure and the manpower are often inappropriate. A disfunction results which may seem nearly insoluble. Very often there seems to be no one with the power or understanding required to resolve a particular dilemma. Fatalism consequently may overtake officials in the bureaucracy, who live almost hopelessly with grossly unsatisfactary situations.

Civil service. The quality and quantity of civil service personnel importantly influence the efficiency of any government's operations and decision-making. In many developing nations, the civil service salary structure is not sufficient to provide a living wage for

a man and his family. As a result he must hold one or several other jobs, so the time he spends on his government job may be minimal. Also if civil service regulations essentially forbid discharge of a civil service employee no matter how inefficient he may be--which is the usual reality--gross financial distortions take place. Also unless there is some way of objectively assessing qualifications of personnel for jobs and selecting the best candidates--particularly for technical or professional positions in innovative, educational and social programs--politics rather than capability determines appointments.

Unenlightened self-interests. These exist in all human institutions in both less developed and established countries. But they are more pervasive in lands where the government is poorly organized and where pervasive poverty is an insistent incentive for widespread acts of crass self-interest for personal profit. Ranging from outright major corruption, graft, and bribery, to petty decisions made for personal power, these can be difficult to deal with. Competition to manage projects may be motivated by hopes to divert project funds to personal use. Unnecessary trips may be taken or seminars held to collect per diem authorized for them. Because a less developed country has limited resources, it usually has limited control processes, poor accounting, and inadequate feedbacks to top management. Consequently opportunities for this type of activity are usually much greater than in established countries. An example of such inadequate feedbacks is seen in governments that operate on a cash system rather than a voucher or

or check system. Under such financial procedure a tremendous premium must be placed on honesty in the presence of much poverty, even at the expense of efficiency. Both are hard to find, though not impossible, in any given civil servant.

4.1.11 Personnel qualifications. In numerous less developed countries the top governmental officials include only a few truly qualified people, often educated abroad. Often they are forced to assume responsibilities considerably in excess of their training and capabilities. They work with many who are completely unqualified. There are shortages of all sorts of personnel for planning, decision making, and technical services. Particularly rare are people with overall system capability and capacity to comprehend the major complex problems and organizational and technical interreleationships in complex educational and social development communications systems. Obviously a long time is needed to find, train, and assign the people required for competent operation of programs in these fields. A lengthy "institution building" phase is needed for each organizational unit which is to be involved in the overall implementation of a system, a considerably longer time than is required in an established country with a higher general level of education.

4.2 Economic and planning problems. The issues about the flow of monetary and planning information fall generally into three classifications: costing, financing, and planning.

4.2.1 Costing problems.

Poor cost data. Reasonably complete costing data for planning and budgeting are not available to officials of the central government in most less developed countries. This is particularly true of local costs, such as those involved in construction or road building, because these may vary widely depending upon both labor rates and materials to be used. In addition costs of electricity, equipment, and transportation may also vary widely and data is often not available at the central government location. Thus a major exercise is often required to assemble the costing team and the data necessary for even rough estimates of total costs of alternative systems.

Statistics. These are often unavailable or inadequate concerning even such vital matters as population distribution, number and types of schools, or characteristics of the labor force. Data on electrification, road, and industrial development may be out of date or incomplete. The job of planning in less developed countries usually involves extra effort in obtaining basic statistics which would be available in established nations. Also it is often necessary to design every step of data collection--collection, processing, and retrieval. Only when systems are devised after much consideration of reliable data can reasonable decisions among alternatives be made.

Forecasting uncertainties. Particularly in a less developed country, the future is extremely difficult to forecast. Especially is this true when so much development depends upon obtaining either foreign assistance or foreign private capital, both of which are hard to schedule.

There are also technical forecasting difficulties which will be dealt with later. Uncertainties involving implementation and use of a national communications system complicate the determination of benefits and effectiveness.

Inflation. Inflation may force drastic changes in the costing evaluations done in initial project planning. Even in a country as sophisticated as India, there is today no good figure for the total costs of the satellite experiment they are planning to run in 1974, even though planning for that system has been underway for a number of years. Inflation is a chief reason for this.

4.2.2 High initial costs. The high initial costs for a national communications system, and the long time which must pass before useful concrete results are shown (perhaps five years) are both serious factors to be dealt with. Pilot projects of some sorts are unfeasible because they require much higher unit costs than a complete system and at times contribute little new information. Cost to build up a backlog of program materials in preparation for educational or other uses of a system may be very high for one or two years prior to system implementation, without any results being apparent whatsoever. Finally, high start-up costs involved in initial construction installation, and checkout of an electronic communications system and training of teachers and other personnel to operate and use it must be borne. Budgeting for such costs creates concern on the part of many budget analysts who are not accustomed to such major investments without any appreciable returns early in the program.

4.2.3 Cost allocation difficulties. In a government where costs are normally allocated and budgeted to individual departments or ministries it is very difficult to apportion cost allocation among sev-several using agencies. A whole new cost accounting procedure may therefore be required when a communications system is considered. An allocation based on hours of channel use may be recommended, but this has drawbacks if the costs of programming differ for the various types of educational and social development programs.

4.2.4 Long-term cost implications. Deciding to implement an electronic communications system implies long-term cost commitments. Because of uncertainties about these some officials have been unwilling even to begin a study of alternative systems. A few such long-term cost categories are:

Maintenance and operation. Maintenance and operational costs must be carefully considered for whatever type of system is planned. Although no general rule can be drawn, over a ten year period they may equal or exceed the total initial cost of the system. Thus the obligation of funds necessary for adequate maintenance and operation (including labor, parts, materials, power, vehicles, equipment, new software and other items) must be carefully planned and budgeted. Failure to do can result in an expensive system being only marginally operable and generally discrediting its planners, operators, and maintainers. Costs of anticipated inflation must definitely be factored into these

costs to insure that a fixed maintenance budget does not result in ever-decreasing quality of maintenance as basic costs keep rising.

Upgrading costs. When the system becomes operational inevitably deficiencies will appear which demand that the system be upgraded. Failure to recognize this and allow for it in budgeting may require the continued use of inadequate programs and thus jeopardize the success of the system.

Eventual replacement costs. Although replacement costs of equipment can probably be reasonably predicted and amortized over the useful life of that equipment, the useful life of curricular and programming materials is less easy to predict. Thus in addition to routine upgrading of materials and programs, provision should be made for amortization and eventual replacement of whole segments of the programming packages as rapidity of change overtakes these rapidly obsolescent materials.

4.2.5 Financing problems. In addition to difficulties in determining actual and projected costs, obtaining the resources, both local and foreign are invariably major concerns. Indeed it is usually the heart of the matter. Local currency budgets of less developed nations are totally inadequate to meet even current expenditures; foreign exchange is normally in short supply; and foreign assistance is too often restricted for uses most beneficial to that foreign government providing that assistance. Thus it is hard to initiate even the earliest planning about the financing of a major new system. Planners may try each year,

when the budget is made up to have some seed money included to start on projects that would have long-term implications. But it is hard often to find for an initial study in a very tight budget. It was then necessary to try to get foreign assistance for such a study, but this may be hard to obtain until some local money is committed.

Local currency. Budgeting local currency requirements for communications systems is often complex, especially if items must appear in national, provincial, and local budgets. The fact that large budget items are needed for implementation of communications before commensurate savings are shown in routine implementation budgets, which will be affected by operation of the communications systems, requires major budget decisions which are traumatic. Integration of these budgets is particularly difficult if the budget approval authorities are scattered throughout a large country.

Foreign exchange. Inasmuch as a great deal or all the equipment required for an electronic communications system must be imported to a less developed country from abroad, significant amounts of foreign exchange are required. Designation of one central agency to handle this entire procurement is advantageous, but this agency must have the necessary foreign exchange in order to operate effectively in a highly competitive market.

Foreign assistance. The planning and implementation of national communications systems are favorite projects for most multilateral and bilateral foreign assistance programs. Particularly the supplying of equipment or the construction of school buildings are attractive to them.

Obviously bilateral sources are interested in promoting this sale of equipment from their own national electronic industries. The software portion of a national communications system, however, is generally much less attractive, although some foreign assistance agencies are willing to provide existing software packages, or perhaps to equip software production facilities, such as radio or television studios, or printing facilities. The bulk of the cost of software production, principally consisting of development and personnel costs, usually must be borne by the developing nation itself. This constitutes a large contribution by the local country. Recognition, identification, and estimation of these costs is a prerequisite to good systems planning and highly essential if adequate foreign assistance budgets are to be obtained.

4.2.6 Quantification of benefits and effectiveness.

Difficulties in identifying and quantifying the benefits and effectiveness of national communications systems as applied to social development, as previously discussed, constitute major difficulties in developing economic justifications for national communications systems.[9] One useful approach in attempting to solve these difficulties is to use an "output orientation." This is an approach whereby an educational system is not analyzed traditionally in terms of the numbers of its schools, teachers, and budgets, but rather in terms of the numbers of its graduates with certain specified skills or of its dropouts with other lesser skills. If each social development program is analyzed in terms of results rather than efforts, effectiveness can be measured.

4.2.7 Trade-off analysis.

The difficulties in establishing both the costs and benefits or effectiveness of instructional systems (which we have discussed above and also in Chapters IV and V) are compounded when one attempts to analyze the trade-offs in social development utility among costs on the one hand and benefits or effectiveness on the other. The differences, for example, between the benefits of real-time as compared to delayed time communications, or between sound only as compared to sound, pictures, and motion are extremely difficult to evaluate. In many cases informed judgments are adequate. In some cases quasiquantitative approaches are required, such as the use of a model for decision-making.[10]

4.2.8 Planning complexity.

Not only do communications systems require long-term planning but the complexities of planning and using a communications system in a less developed country generally require establishment of new planning teams or organizations which have not existed previously. These employ technical personnel to plan the system itself, programming personnel to prepare the content of the material to be carried over the system, and management and administrative personnel to conduct costing, financing, operation, and maintenance of the system. Even the problem of obtaining foreign advisory assistance is complicated by the fact that each international agency normally is willing to fund only limited aspects of the planning activity and therefore project preparation advisors must involve a number of different international agencies.

A warning here may be appropriate. Sectoral responsibilities are often delegated completely to sectoral departments. A nation's agricultural sector may be controlled completely to the agriculture department; the educational sector to the education department, and so forth. Unless a supradepartmental agency is set up to coordinate these activities and effectively evaluate the relative priorities among them, confusion and delays will undoubtedly result. Normally a national planning agency, a national communications board, or a similar organization is essential to insure the necessary coordination among various governmental departments in the conceptualization and planning of a national communications system. Anything less will seldom, if ever, be adequate.

4.3 Social and cultural problems.

Many social and cultural characteristics of the population in a developing country may create major obstacles to the conceptualization, planning, and implementation of a national communications system for a social development. These vary widely among nations. Any attempt to generalize among them would be fraught with unsupportable assumptions. There are certain characteristics, however, which can be developed from a limited observation, which then can be used as examples of the types of social and cultural characteristics which must be considered in any specific case.

Attempts by foreigners to assess these characteristics in any given country are risky. Interdisciplinary teams involving both foreigners and nationals of that country are usually required to understand really the key characteristics that should be considered in this planning effort.

The following paragraphs contain a list of possible types of social and cultural problems, none of which probably apply in total to any given country but others of which may apply to a specific person.

4.3.1 Lack of Long-range planning.

Many less developed countries, especially those whose recent history has included political, social, or economic unrest, seriously lack both orientation toward the future and understanding of the fact that planning is a way of altering the future. An improvished hand-to-mouth existance or a cultural fatalism make the people concerned only for the immediate present and thus unable to comprehend or devote any physical or mental energy to planning for the future. This may be in varying degrees at several levels of government. Usually at the highest levels a greater orientation toward the future develops among the more highly educated leaders. Even they, however, often deal in months or at the most a few years rather than taking a long-term perspective necessary to initiate major programs which will fundamentally improve the country. Decision makers in such governments rarely allocate sufficient manpower, funding, and other resources to long-range planning. Instead "the immediate takes precedence over the important" and most of the resources are utilized to achieve immediate objectives.

4.3.2 Lack of "systems comprehension".

It is sometimes difficult to find within the government of less developed countries sufficient personnel of perspective broad enough to get an overall "system comprehension" of all the ramifications of planning

and utiliziation of a national communications system. Often top governmental personnel have been educated abroad in various specialities. They may be excellent economists, sociologists, communications engineers, or other similar highly trained specialists. But systems analysts are usually trained specialists who have developed capability first in one speciality and have later gained more knowledge and experience in several other disciplines. This takes time, and many less developed countries have not yet had the time to obtain or train the comprehensively oriented personnel needed. As a result governmental officials feel under stress because they must make decisions about complex issues conceiving which they do not feel professionally competent.

4.3.3 Lack of organizational hierarchy.

Many less developed nations, recently evolving from a purely agrarian society, have a social and cultural pattern based on cooperation with minimal organizational hierarchy. The mutual self-help philosophy which prevails in the agrarian village economy implies that no man be higher or lower than his fellows. Often this makes it difficult to create an organizational structural hierarchy that distinguishes chiefs from supervisors and workers. Often those responsible for direction of others are reluctant to impose their control upon the personnel responsible to them and organizational effectiveness consequently suffers.

Such cultural attitudes produce some organizational situations which are completely incomprehensible to those familiar with management practices in Europe or the United States. For instance, in a standard hierarchical organization chart we normally consider that the lines of

interconnection and relationship are the most significant, but in some less developed countries the boxes are the most significant. They symbolize walls which seem comfortably to seal their organizational units off as much as possible from the outside world above, below, and beside them.

4.3.4 Individual fears and apprehensions.

Many social and cultural characteristics are expressed in fears and apprehensions of individual persons regarding the responsibilities of governmental office. These fall into a number of categories, a few of which are listed below:

Lack of comprehension. This, of course, is a common human characteristic of employees and officials in all countries. The lack of comprehension of a problem by a government official in a less developed country is particularly critical when he is embarrassed to admit his lack of understanding. Often short-sighted or erroneous decisions are made in order to avoid admission of ignorance. Recognition of this is essential when one is evaluating trade-offs among complexly differing options concerning alternative national instructional systems.

Lack of expertise in technology. Technology world-wide is developing with great rapidity. It is easily understandable that officials of less developed nations are, consequently, unaware of technological advances which may be part of the common knowledge in established countries. It takes unusual effort to keep up-to-date in a less developed country where access to even the most elementary journals, books, seminars, or other learning resources is difficult. Thus, for any developing country, major

efforts must be made by both the country itself and those international agencies involved in assistance to be sure that government officials in a less developed country are aware of the current state of the art and instructional communications technology.

Responsibility for decisions or actions. Cultural characteristics described often above--lack of comprehension and technologica expertise-render officials unwilling to take responsibility. A variety of devious means may delay apparently obvious decisions or actions for inordinately long periods. This can be particularly frustrating when one is pursuing a program of interlocking decision-making among various units critical to achievement of an overall plan on schedule.

4.3.5 Dysfunctionalism.

In some less developed countries the government has never functioned effectively. The people get used to this and do not expect that it will operate either rationally or well. That is, acceptance of dysfunctionalism becomes a social and cultural characteristic. Problems which seem very serious to a foreigner used to the governmental and corporate organization of established societies may seem perfectly natural and quite acceptable to a local national. Many leaders in less developed countries are just as frustrated with this characteristic, if not more so, than their foreign colleagues, but they are unable to change the attitude of the average citizen which diminishes their motivation to strive for better government.

4.3.6 Linguistic diversity.

In a less developed country where many languages are used, the linguistic diversity, especially if there is no common national language,

is a real problem in planning a national communications system. Especially in a country like India, which is currently planning a major satellite experiment, the linguistic differences among various sections of the country create major design constraints. This factor has two significant aspects. If in a particular country any language is universally acceptable, a communications system can help promote the use of that language more widely than would be possible without it. In the absence of such a common language, however, the several languages represent major cultural and ethnic diversities which are difficult to bridge with common programming even if the programming is translated into each of the languages.

4.3.7 Cultural and ethnic diversity.

In all countries cultural and ethnic diversities create problems in developing common communications and programming. The traditional and historical divisions, animosities, and conflicts among various ethnic elements of the population often create such wide gaps in cultural characteristics as to require individual treatment in almost every aspect of program development. This can be extremely costly and time consuming in the planning of educational program materials to be carried over a national communications system. Major efforts must be made to establish the largest possible common base of acceptable material so that individual adaptations will be minimized and thus be most easily and inexpensively accomplished.

4.3.8 Resistance to change.

Related closely to the lack of long-range planning in the cultural traditions is the great resistance to change that exists in many individuals and institutions in most less developed countries. Attention is directed more to the past than to the future. Past experience has involved a certain degree of security. The prospect of change is both frightening and difficult to comprehend. With ever-increasing rates of change impinging on the society, the future shock so aptly described by Toffler becomes very apparent in social and cultural disruption.[11] Particularly where institutions, such as the educational system, have been very painstakingly developed with great effort based on a colonial model, people are reluctant to abandon the security of that model for any other system, or lifestyle. Instructional television was resisted at first by teachers in Samoa, El Savador, and Ivory Coast, who feared it would displease them. A working paper on the education-sector of less developed nations prepared by the staff of the World Bank notes that many of them show[12] "..persistence of institutional forms, school system structures, teaching methods and curricula derived largely from European practice of an earlier era and to a great extent irrelevant to present day needs. In different ways, but with comparable effect, both the former colonies and the historically independent developing countries suffer from a lack of responsiveness to changed conditions. Both types of country have inherited or adopted educational systems designed for an elite--in the historically independent countries usually a landed or commercial upper class; in the former colonies a cadre of civil servants. In both cases, with the change to a mass

learning clientele, a substantial proportion of the students in school are being miseducated. The content of primary and secondary courses, heavily dominated by the questions on qualifying examinations, is still drawn to a great extent from the developed world, which is remote from the experience of today's student, especially the rural peasant child, still living in a primitive condition of life. The heavy reliance on examinations encourages rote learning of irrelevant information. Even in technical courses adherence to standards and practices set in the developed countries inhibits the education of students to solve the problems of their own environments in more appropriate ways. The fact that these practices are often the choice of local people does not diminish their bad effects.

"The public has increasingly come to consider education as a right and a school place as the entrance ticket to a better life in the monetary sector of the economy. Parents are generally well aware of the growing unemployment among school graduates, but the gap between the subsistence and monetary sectors is so wide that they may still consider that it pays to provide secondary and higher education for their children on the off-chance that one may secure a job that will enable him to help his less fortunate brothers and sisters. To a very large extent these views have been accepted by the governments and are reflected in their education policies."

"Cultural and ethnic demands may furthermore force the borrower to establish educational institutions--secondary schools as well as university departments--in areas which for a long time to come will lack the economic

resources and the population necessary for a satisfactory development. In some instances schools may be seen as a device for keeping young people out of trouble."

"Innovations, which are seen by outsiders as necessary to remedy qualitative and financial problems, may often be resisted by the developing country--and particularly by teachers and ministry officials--as changes which would downgrade the system and endanger vested interests. They may refuse to participate in experiments which they feel should be tried out in other countries which could better afford failures. They are particularly sensitive to proposed changes in examination systems since these may seem to imply a retreat from accepted world standards. This demand for international equivalence in examinations is undoubtedly hampering the adjustment of secondary and higher education to local needs but it represents a politically vocal requirement which most African and Asian governments find difficult to resist."

"In the face of the surging demand for education of the masses as rapidly as possible, it is not surprising that very few leaders have stopped to ask, as President Nyerere of Tanzania has done--What kind of society do we wish to create? What can we realistically expect to achieve with our limited resources? How can we fashion our education system so as to maximize its contribution to these ends? Whom shall be educate, for what and how? Instead most governments have sought to replicate what was at hand as widely as they could."

Resistance to change is often unwittingly aggravated by inadequate communications about potential change internally within the government and externally between the government and the people. Many major new development projects have had to deal with opposition or lack of comprehension by the people directly concerned because the government has not been able to communicate fully its implications and consequences. Recently the United Nations has recognized this problem and established a Development Support Information Service to analyze and assist nations in providing the required communications to overcome this particular failing of many past development programs.

4.3.9 Growing needs for increased employment.

As the populations in many less developed countries grow rapidly, the labor surplus also swells. As this is increasingly recognized, opposition rises to technological solutions which depend on capital-intensive rather than labor-intensive solutions.[13] Governmental planning agencies are more and more concerned about this problem, but it is not yet being effectively addressed in governmental decision-making in many countries. High technology alternatives, whether they be bulldozers for road construction or satellites for communications, continue to be tantalizingly attractive because of the modernity of their approach, regardless of their capital-intensive nature. Often they are chosen over perhaps less glamorous but more practical alternatives which could utilize a greater portion of the available labor force.

4.3.10 Income distribution.

Another increasingly recognized social problem is the widening gap in income distribution in most less developed countries. While the increase in gross national product may be appreciable over a year, that increase results in considerably higher incomes for a small number of people in the higher and middle income classes, and may or may not result in any change whatsoever in the income of the great mass of the population. This can pose a major problem to planners of communications systems, for if communications services become widespread, there is a real fear that the rising expectations of the populace may well be frustrated by the system which denies them any appreciable share of the increasing wealth and thus their aspirations will turn into frustration which causes increasing social unrest.

4.4 Technical problems.

Many of the problems cited above eventually end up as technical issues. These are the actual issues concerned with planning, design, and implementation of the communications system itself. Among the more commonly encountered problems are the following:

4.4.1 Real-time versus non-real time requirements.

Specific distinction between real-time and nonreal-time communications requirements is a difficult but necessary task. It necessitates a detailed analysis of each social development program, starting from its objectives and going on to the specific requirements for each program unit. These can then be consolidated into those units which require real-time services and those which do not. A CAI interaction with a student

must be in real time, the computer responding within a few seconds at the most. A videotape lecture, on the other hand can ordinarily be prepared months before it is used. Immediacy of interaction costs money, and therefore good cost-effectiveness analysis demands a critical analysis of every communications requirement to determine whether it must be met in real time. Only if there are many priority demands for such services is there justification for a nationwide real-time communications system.

4.4.2 System design requirements.

Having established the immediacy requirements, the other system performance requirements must be determined. Obviously a system for radio transmission only is far different from one for both audio and still pictures. That differs from one which transmits standard black-and-white television, which differs from a color television system. Each extension of system performance is expensive and requires careful analysis before it is acted on. Too often in the past less developed countries have decided to set up full-scale television systems without considering radio and other alternatives. Thus, they have established requirements for systems which are continually expensive to program and to maintain and often cannot be used to their full capability because they are not well adapted for the needs of the social development program. Often a well-designed national radio system, supplemented by printed and written materials, can adequately perform the essential functions required for national programs at far lower initial and annual costs than a nationwide television system.

4.4.3 Data and information problems.

In the technical design of the system, data and technical information shortages are often critical. In comparison with established countries, technical design information and local statistical data are far less accessible in less developed countries. Recognition of this fact by international assistance agencies can be of great help to less developed countries, for they can provide the funds and technical aid needed to provide such data.

4.4.4 Technological forecasting problems.

The lack of sophistication in technological forecasting in less developed countries seriously limits their capabilities to recognize all the available options from which they may choose. For example, the little known capability of FM radio to carry visual as well as audio information opens up a range of potential low-cost capability which may well be a promising option for less developed countries. While on the one hand caution must be used in employing completely unproven technologies, it would be an equal mistake to design a system that would be obsolete before its installation was completed. Judicious selection of the appropriate media is a most important design decision.

4.4.5 Systems design problems.

A number of systems problems will be encountered as its design proceeds. Each of these will significantly affect the overall approach. A few are indicated below.

Reliability. When a national communications system is used for a vital, integral application in a social development program, rather than a supplemental, optional application, reliability of the system becomes crucial. If the failure would halt the program, sufficient reliability and back-up must be designed into the system to prevent such a catastrophic failure.

In a satellite-based system, the entire configuration of ground-based transmitter, satellite, and earth station receivers must be designed as a simple multicomponent entity. Transmitting and receiving ground station units must have sufficient backup and reliability of design to insure continued operation. The satellite itself creates a special problem. Provision of a backup satellite is normally not economical yet the consequences of an unexpected catastrophic failure of a satellite must be clearly analyzed and provisions made for remedial action in such a case. Although the highly developed techniques of reliability design used in established countries may be considered too sophisticated by some personnel in less developed countries who are not familiar with them, the extra money spent on a total system reliability analysis during the design phase will prove well worth while when the system goes into full operation.

Maintainability. The maintainability of the system, involving facilities, personnel, training, spare components, and integral design elements of the system--is related to the reliability but it is a separate matter. The design of the maintenance system--the facilities, warehouses, spare parts, distribution procedures, and backup equipment of each operating unit or maintenance depot--is necessarily part of the initial system plan.

The operation of the maintenance system must be provided for in the budgetary planning and in personnel training to insure an adequate supply of personnel, parts, and money to maintain the system once it is implemented. Short-sightedness in this area can be disastrous, with politically and socially serious consequences, if massive expenditures have been incurred in implementing the system and then it does not measure up to expected performance as a result of poor maintenance.

Operability. Often significant cost trade-offs are related to the system design. Increased ease of its operation may be bought by increased initial costs. This applies to studio equipment, mobile recording equipment, transmitting equipment, and some receiving equipment. For each of these the sophistication of the personnel required and the consequent training requirements must be analyzed. They must be viewed as a trade-off between more expensive and easier to operate equipment versus simpler equipment which may have more operational problems but can be handled by people with less sophisticated training. In general, the simplest types of equipments are preferable.

4.4.6 Programming.

The programming or software of the system, by which is meant the entire activity related to the content to be carried by the system, is naturally one of the largest and most significant of the elements in the overall system design. Decisions as to whether programs preparation should be centralized or decentralized, the quality of program material to be provided, the quality of studio facilities to be used, and the capacity, flexibility, and variety of types of program material to be provided, all require systems trade-offs and evaluations.

Creativity. Programming requires a great deal of spontaneous creativity as well as disciplined work. An inspired programmer, working with an absolute minimum of facilities, can create much more effective programming, than a pedestrian or dull programmer working with the most sophisticated equipment. Thus, while centralized major programming production facilities may well be the most effective, procedures should be set up with enough flexibility to take advantage of creativity wherever it may be found in the less developed country.

Centralization. Sometimes decentralization of programming is required because of language. In other cases it may be necessitated by geographical features of the country, or social, cultural, or ethnic differences. Whatever the reasons the requirements must be reflected in the overall systems design. Maximum advantage should be taken wherever possible of centralized facilities and program generation because this is expensive, and whenever replication can be avoided that is highly desirable. Every country, therefore, should have at least one major centralized programming facility where the best available personnel can be gathered together to generate as much widely usable instructional materials as is feasible.

At least two possible options exist for handling regional, provincial, or locally generated materials. One is to locate at the national production center additional personnel and facilities for making the local adaptations, be they translations or actual programmatic changes and adaptations. Though this has the advantage of centralization and efficiency, and may be the least expensive alternative, it may require displacement of personnel or may lose "the local touch" often considered essential by local authorities and teachers.

A second option is to provide decentralized production facilities which can adapt for local needs program materials which were prepared centrally. A word of caution is appropriate here, however. Past experience has shown that if the decentralized personnel or facilities are considerably lower in quality than the central unit, the local adaptations may be very inadequate.

4.4.7 Electricity supply.

Whether or not stable, reliable, electric power is available throughout the country is a question of major importance in system planning and design. If the country has no electricity outside the major cities, the provision of a network of ground transmitting stations or a terrestrial communications system may be difficult and costly. Reliable operation of a local generator plant for a transmitting station is not easy. Sufficient power units must be available to insure uninterrupted operation several hours a day. This may require a number of standby units. Providing fuel and insuring availability of parts for maintenance require a substantial transportation capability. Power units require major overhaul periodically and this often requires equipment and facilities considerably beyond the local capability. Thus the provision of major national and regional overhaul shops and traveling personnel who are capable of performing overhaul must be considered.

For receivers which are operated from batteries rather than from a central power source, the provision of batteries is another design consideration. The quantity of batteries required in a large country may well necessitate establishment of a national battery industry. Dependable distribution of these batteries is vital. It often can be integrated

with the maintenance procedures for repair and replacement of inoperable receiving equipment. Batteries which can be replaced locally by inexperienced personnel are desirable in order to minimize demand for more experienced maintenance personnel. The shelf life of batteries from the time of their production to the time of ultimate utilization needs to be taken into consideration, as well as possible advantages of rechargeable battery packs and other electrical power alternatives.

4.4.8 System scheduling.

Scheduling problems of the various requirements for time utilization of the national communications system are almost certain to be complex. Educational uses in the formal school system must be scheduled for the times that children are in the schools, whereas agricultural broadcasts are necessarily timed for periods when farmers are not working in their fields. The phasing of air time for various uses and the resolution of priorities and conflicts for use of limited numbers of channels are significant questions which must be considered during the design of the national system. If local recording facilities are provided, the central studios can broadcast programs at one time, they can be recorded, then reused whenever and as often as may be required by local time needs. For countries which span one or more time zones, an additional factor of scheduling is introduced. Usually these countries have other regional reasons for decentralizing program preparation and transmission.

4.4.9 Technical and operational trade-offs.

A large number of possible technical and operational trade-offs need to be reviewed in planning a national communications system for educational and other social development purposes. They vitally affect the

eventual cost-effectiveness of the system. As examples shall now briefly discuss three types of such trade-offs below:

Satellite ground terminal options. A number of possible optional configurations of a satellite system are expected to be available by the time any less developed country is ready to set up a satellite based communication system. These options included:

- Use of an INTELSAT (or INTERSPUTNIK) satellite on an allocated channel basis, with either the regular coverage or a spot beam coverage.
- Use of a shared regional or international satellite covering various countries with one or more major receiving stations in any given country and a local ground-based distribution system.
- Use of a domestic satellite with one or more local ground stations interconnected with local terrestrial distribution systems.
- Direct broadcast by a satellite to individual receivers located in schools, homes, or elsewhere, without employing any form of terrestrial distribution.
- Hybrid systems involving a mixture of any or all of the above.

Decisions among such options often revolve around such a critical factor as the degree of centralization or decentralization which is optimal in the programming for the country involved.

Terrestrial systems options. A wide variety of terrestrial distribution systems exists. Depending on whether radio or television is used, these include microwave, tropospheric scatter, various types

of land lines or cable systems, or manual distribution procedures such as the mails or carriers. Evaluation of the trade-offs among these alternatives may involve consideration of local transportation, available social services, existing facilities, or available programming and production expertise purely technical or cost requirements.

Receiver configuration options. At the ultimate receiving points for the communications system, the number of receivers is large and therefore their costs loom large in the total budget system. Such a question as whether to use one receiver to service an entire school with speakers in each classroom or individual receivers in each classroom is typical of the type of issue which must be considered. Inasmuch as classrooms in many less developed countries have practically no sound insulation between adjacent classrooms, the arrangement and type of speakers used in classrooms is important if the programs being heard in one room are not to disturb students in another room. Possibly the use of several distributed small speakers operating at a moderate intensity rather than one loud, large speaker may be the most desirable design. Each such question must be analyzed for each individual application and location.

4.4.10 Propagation problems.

A number of issues about electromagnetic wave propagation are critical in the overall systems planning and design.[14] A few are briefly considered below:

Frequency spectrum availability and control. It is essential that suitable frequencies for the various channels in the system be available. For satellite systems the frequencies assigned from transmitter-to-space-to-receiver channels are significant determinants of system design and costs. Frequency interference may well place constraints on system preformance as use of satellites increases. For terrestrial systems there are significant differences in operation and effectiveness between, for example, short-wave and medium-wave transmitting stations. In television there are differences in equipment and costs between the UHF and VHF transmissions.

Interference-free operation is of course highly desirable for a national communications system. For smaller countries where signals spill over to and from adjacent countries, international frequency allocation and control procedures are essential. Within the country organizations and equipment are needed for frequency monitoring, allocation, and control to prevent unauthorized transmissions, either intentional or unintentional, from interfering with the national communications systems operation.

Signal strength and message quality. Inherent in the design of the system is the question of how powerful the transmitting and receiving equipment should be as well as the type of antennas to be used to insure adequate signal strength at each receiving location. Since the quality of the signal received is basic to the systems engineering effectiveness and acceptability, a good system design should enable a reasonably high quality signal to be received.

Coverage. The question of the percentage of the population covered by the system is directly related to signal propagation characteristics. Especially in a hilly or mountainous country, terrestrial propagation problems may seriously limit availability of adequate signals in areas when propagation is difficult. Choices need to be made between large high-power transmitting stations and more dispersed smaller-power transmitting stations, depending on actual coverage characteristic coverage of each. This problem is avoided to a great extent in a satellite-based system, since direct reception from the satellite is usually possible at any location. But if a hybrid satellite and local distribution system is employed, these problems still are significant, even in a satellite-based system. As the population coverage climbs towards 100 percent, the marginal costs will often rise exponentially. It becomes a significant decision of national social policy as to what should be the ultimate percentage coverage achieved by the system. The social consequences of denying a portion of the population the advantages enjoyed by the other citizens must be seriously weighed against the high costs of total coverage.

4.5 Social development program problems.

In addition to direct communications systems problems, there are a number of associated problems related to the nature social development programs. Some of these are as follows:

4.5.1 Establishing objectives.

One chief issue which should be faced during the design state of a system is how to analyze specifically its objectives. Few people in the less developed countries have been taught the need for outlining precise

rather than nebulous objectives, or the methodology for delineating them. Programming for transmission over a communications medium requires much more discipline and thinking about the content than is usual in educational activities. This precision can sharpen controversies among divergent schools of thought. It may well create significant conflicts within educational and other social development agencies as both different viewpoints and different procedures are proposed and supported by various factions.

4.5.2 Equitable allocation of benefits.

Conflicts in priorities encountered during the initial conceptualization and justification stages between various competing social development programs will sharpen even more intensively during the design phase. Following a commitment actually to employ the system, additional uses will become apparent as the design progresses, and there will be increasing desires to use more of the system's capability. As the programmers get to work the seemingly adequate time slots previously allocated will become less and less adequate. Pressures will grow for reallocation of priorities or for expansion of the system. Adequate coordinating procedures can keep this from becoming a crisis.

4.5.3 Organization resistance to change.

Making a major communications system available to a nation's social development programs can and should bring about a drastic change in their whole method of operation if it is properly designed.[15] Such alterations of previous life patterns predictably evoke resistance to change. This takes a number of forms, of which a few are described below.

Organizational inertia. New organizational structures, responsibilities, and opportunities will be created by the new system as others are discontinued. Obviously this kind of change creates great difficulties and conflicts at every level. Because many organizational structures in the governments of less developed countries are inherited from prior colonial regimes, often the procedures for changing those structures are not so well established as they might be had the structures evolved locally. Thus the bureaucratic difficulties of actually achieving such changes, setting up new units, and increasing manpower ceilings can often seriously delay the full implementation of a new communications system.

Teacher fears and resistance. Those who work directly with the students or other clients--the teachers, social workers, and community development workers--often are the persons who put up the most resistance against the use of new information processing technologies. Since a large number of people will be affected, communications about the system before it is introduced are of vital importance. Misinformation is often circulated more rapidly than truth. Fears of being replaced, exploited, or facing other traumatic changes in work and life style often circulate within a country well in advance of the truth about the roles of workers in the system. These fears, once stated, create a wall of opposition which is often much more difficult to break down than it would have been had adequate communication been carried out before the fears were raised.

Loss of local control. Many social development programs, not only schools but community programs as well, have a distinctly local

flavor, depending on the inclinations and capabilities of the personnel on the spot. With the introduction of a major communications system there are often fears, in many cases well founded, that local control will be lost and the programming on the system will not be relevant to the needs of particular communities. Provisions must therefore be made in the system design and procedures for the appropriate local participation so that these fears will turn out to be unjustified.

Pressures for academic orientation in education. Though this problem is unique to the formal educational system, varieties of it appear in some other social development programs. A tradition, often inherited from colonial times, of academic education as the way to get ahead persists in many less developed countries. It often sets the school system curricular design and orientation even though the number of people who benefit by such a curriculum are a small percentage of the population. Consequently the school system does not effectively serve the development needs of the country. Unfortunately many officials who make decisions about the educational system are themselves products of its academic stream. They seek to justify and strengthen it to the benefit of those students who are getting academic education rather than broaden it to provide vocational education as well, which is also needed by the country. Many countries are currently plagued with serious shortages shortages of qualified technicians and skilled workers while they have surpluses of graduates, from academically oriented schools, who lack the basic capabilities required. This situation is well illustrated by a tabulation of 17,000 questionnaires distributed in conjunction with an

education assessment project in Indonesia. An overwhelming majority of the responses maintained that the educational system should provide vocational and technical schooling relevant to the developmental needs of the country. At the same time, however, they overwhelmingly indicated their desire that their own children attend academically oriented schools.

4.5.4 Integration with other media. Since the entire programs of social development programs are rarely, if ever, carried on communications media, redesign of the remainder of such programs which use a national communications system is necessary. If, for example, in a schoolroom 50 percent of the curricular material is presented by radio or television, the other 50 percent must be considerably redesigned to fit with it. This must usually be done locally. Such re-design creates a considerable strain on teachers and administrators in the schools. It requires them to adapt their previous habits, knowledge, and materials to the new instructional methods. Such changes take time. Until it is complete the communications system will probably operate with diminished effectiveness.

4.5.5 Uncharted futures.

One of the greatest difficulties in introducing communications systems for education and other sorts of social development is that much of the experience gained in the past really does not adequately serve to determine the future direction of programs.[16] For example, the alternatives to schools for formal education are still not well explored or developed. Some of the less developed countries, for example, are just now beginning to experiment with plans like the Open University or schools without walls. But these are taking place in highly developed, highly

sophisticated environments. While the communications medium itself might be an outstanding vehicle to introduce changes, its capabilities and alternatives are not yet well enough understood to make it clear how to make it most effective.

4.6 Implementation and utilization problems.

While most of the issues discussed above are usually first encountered during the initial conceptualization and planning stages of the system, new issues are encountered when the implementation and operational phases of the system ensue. Some of them are discussed below.

4.6.1 Scheduling and funding delays.

Uusually the implementation of a system must proceed on a carefully coordinated schedule. If either materials, personnel, or fund shortages cause changes in this schedule, interrelated problems may develop which can be serious. For instance, a school system may be operating under intolerable conditions of overcrowding or inadequate facilities, counting heavily on the new media-oriented program to relieve those pressures. Delays can be very distressing to such a school system.

4.6.2 Maintenance.

As previously discussed, in the design stage maintenance planning is essential for adequate operation of the system. In the implementation and utilization stages, however, numerous problems crop up in trying to carry out the best maintenance plan. These concern maintenance organization, transportation, availability of parts, facilities, and trained personnel. Delays in obtaining required funding for purchase of needed materials can often be critical. In the end probably the degree of success of system maintenance, more than almost any other factor, will influence the

effectiveness of the system. Thus constant struggles are necessary to continue a high enough priority in the national funding for maintenance budgets so that maintenance will be adequate.

4.6.3 Supplemental materials coordination.

As previously discussed, the communications system by itself is not ordinarily adequate for most social development programs. To be effective it usually requires also the transportation of supplemental materials and personnel. The traditional shortcomings of transportation in less developed countries may well decrease the effectiveness of system performance. Deterioration of materials en route or in storage, lack of adequate storage, and a hundred other things can create problems as well.

4.6.4 Changes.

Changes can seriously interfere with system implementation. Organizational and policy changes which cause major system revisions; escalating costs which create budgetary shortages, systems changes, or delays; changing system requirements which designers recognize as they progress in their planning--all of these require an adequate organization to evaluate each change and adjust to it.

4.6.5 Monitoring and evaluation.

A well designed social development program needs monitoring and evaluation of its results with feedback of information on them to the planners, programmers, and decision-makers. This must be handled by organizations which are separate from those directly responsible for creation of the program in the first place, so that the creator is not also the critic. A relatively independent quality control organization is essential if the quality of the program is to be constantly improved.

5. Approaches to Solutions

The above complex and interrelated array of problems and issues may understandably seem overwhelming to officials of any less developed country. Though it is obviously much easier to state than to achieve, conflicts must be resolved, fears overcome, complexities faced, and resources found. Often simplification--breaking the problems down into their basic elements relating to materials, land, people, engineering aspects, information, and money--is a useful approach.

Rather than trying to enumerate possible solutions on a problem-by-problem basis, we outline below a summary problem-solving approach in 12 specific steps. Any government of a less developed country that follows these steps is well on the road to the selection and implementation of an effective national communications and instructional system for education and other social development programs.

5.1 Recognize the complexity of the undertaking.

The complex problems of national communications systems do not necessarily require complex solutions, but they do demand organizational structures and procedures that are sufficiently sophisticated to deal with these complexities. Three suggestions for approaches follow:

5.1.1 Interdepartmental coordination body.

There should be a strong central national governmental interdepartmental coordinating body above the departments or ministries that will be involved in planning and implementing the system. It could be the national planning

agency, if properly staffed, a special coordinating board, or any other similar governmental organization with enough strength and capability properly to coordinate the activities of the many ministries and departments involved. It should have adequate representation from the departments themselves, and from the provincial or state governments.

5.1.2 Information.

Reliable information, available to those who need it, is essential to the successful planning and implementation of a national communication system. This is not only technical information related to the information processing system but applications information related to the social development programs--essential statistics and data from the entire country. Information should be centrally available, although not necessarily stored in one place. Obviously it should include all available data from reliable international bodies and national sources. Unfortunately, many planners consider information gathering to be a peripheral rather than a central function and it is thus inadequately budgeted and staffed. Adequate information for systems planning is as essential as adequate personnel.

5.1.3 Personnel and staffing.

Each department involved in the system should be staffed with adequately trained, competent personnel, with both the technical system and the social development program. These technical personnel should be sufficiently integrated and coordinated that they function effectively together.

5.2 System approach.

A system approach to the total problem is a first essential step.[18] It should not be approached solely from the viewpoint of a communications system or of instructional technology or of itself social development, but of

coordination among all of these. A few of the more pertinent points relevant to such a systems approach may be enumerated.

5.2.1 Relevant questions.

By formulating key questions and then addressing the organization's effort to answering these, much progress can be made in formulating a system approach. A few of these are:

- What are the real objectives of our social development program?
- What can a national communication system contribute to this program?
- How can communications assist in reaching my objectives and solving my problems?
- What could I do differently (and probably better) if I had a communication system?
- How can instructional technology make a major impact on our program?
- How can instructional technology save money for our program?

5.2.2 Interdisciplinary teams.

Opportunities should be seized to form interdisciplinary teams or bring organizations with different specialties together so that a wider viewpoint may be obtained on any problem area. Obviously government officials, engineers, instructional technologists, educators, and other social development program personnel should be brought together. But many less obvious interfield combinations can yield surprisingly effective results, especially when new and innovative uses of technology are being sought.

5.2.3 Usable methodology.

Looking at each major problem area from a methodological as well as a substantive approach often yields fruitful results.[19] Experimentation with different types of decision-making methodology, for example, can be useful. While some areas may be sufficiently well defined that standard economic cost-benefit analyses may yield good results, other areas need different approaches, such as decision trees of various types.[20] For each type of problem there are several possible methodologies, and choice of the appropriate one often requires considerable investigation by people knowledgeable in the available alternatives.

5.2.4 Alternatives in instructional technology--simple and complex.

A common failing in systems planning is the neglect of the simpler alternative technological solutions. For political or technical reasons, modern high technology solutions are often held by officials to be more desirable, and much effort is then spent in justifying them. Increasingly, however, consideration of the need for labor-intensive rather than technological approaches and of the limited resources of the country lead officials to consider the simpler alternatives much more carefully. In some cases just doing more of what is currently being done is the best alternative. In other cases, minor improvements from the use of communications are sufficient. Major change is needed in many cases to provide the quantity and quality of educational services and social development programs that are needed to meet national development objectives. Even revolutionary changes, however, need not necessarily employ the most sophisticated and expensive technology.

5.3 The need for training.

Every less developed country contemplating the use of a communications system for educational and other social development programs needs major training programs. At the earliest possible time, hopefully a year or more before any system implementation, training programs should be started to build cadres of trained personnel of all needed levels.

5.3.1 Lower levels.

Full-fledged training programs abroad and at home can be started with promising younger people who are capable of developing the outlook and initiative to participate in the planning of instructional applications. Fellowships abroad as well as university and special academic work at home are both possible.

5.3.2 Middle levels.

Personnel involved in current governmental activities are usually too committed to be diverted to full-time study, so major symposia, short-term training programs, and short study tours abroad are appropriate ways of building capability at this level.

5.3.3 High levels.

The need for training and education of top level personnel must be recognized, but since they are immersed in administering important operations, they cannot usually be spared for anything other than special presentations which can be tailored to their needs or one or two-day seminars. It would be a mistake, however, to ignore the training needs of personnel at these levels, since often they require up-to-date knowledge about technical and social development matters in order to most rationally make decisions.

5.4 Fear of change.

In one sense it may be easier for a less developed country to introduce change and innovation than it is for an established country which has an entrenched set of institutions which give rise to substantial resistance to change. In any country, however, tremendous amounts of organization and drive are required to produce desirable change. Every possible means to promote an atmosphere conducive to change should be adopted. Seminars on innovation and change, for example, and traditional brainstorming sessions are ways in which change can be promoted and encouraged.[21] One major approach is getting the youth of the country involved, tapping their initiatives and ideas and involving them in governmental processes, thus channeling their aggressiveness constructively.

5.5 Employing available objective external assistance.

A wealth of international information and assistance are available to the countries that are able to make use of it in planning communications for social development. Selecting people with appropriate backgrounds and abilities to interface with international organizations, and centralizing international contacts so that the nation's efforts abroad are coordinated will facilitate the process of obtaining this international information and assistance. Some of the organizations which can be useful are listed below:

5.5.1 International agencies.

Help may come from the United Nations Development Program, the World Bank, regional development banks, and United Nations agencies. Their

activities may sometimes overlap or be in conflict, but a less developed country must do its own evaluating and choose the agencies to work with that can help them most in each area of national development.

5.5.2 Bilateral sources.

Established countries that give bilateral development aid can often be of great service in providing information, technical assistance, and funding. A wealth of technical aid, funding for essential research programs, and technical information may be obtained from a number of different sources prior to actual selection of a communications system. A less developed country should recognize that competitive pressures motivate some countries to promote their own products and services. The recipient country should select the aid best suited to it.

5.5.3 Regional organizations.

A less developed country will usually benefit from joining various regional and other international organizations such as the Asian Broadcasting Union or the European Broadcasting Union. Also it can profitably set up cooperative discussions with other countries in the region interested in similar problems, to learn from their experience some of the alternative approaches which are possible.

5.5.4 Academic institutions.

Universities in other countries can provide assistance, especially when linkages are established between a university in an established nation and academic institutions in a less developed country. Often a small amount of funding from an international agency or a bilateral source can be catalytic, promoting a much more effective effort than a similar investment in nonacademic activities. Interinstitutional liaison

can usefully be established not only between academic institutions, but also between various professional and scientific associations and organizations related to those institutions.

5.5.5 Private corporations.

Most less developed countries are besieged by representatives of private corporations trying to sell their wares. These salesmen may be valuable sources of information. Governmental officials should be careful, however, not to make decisions under pressure from them to make purchases. They are not objective, no matter how much they try to appear so. Their business is to sell products and services so they are biased in favor of what they have to offer. While they will try to influence officials to make quick decisions in their favor, they will also remain available if the officials decide to make objective evaluations of their offerings. As a matter of fact, a corporation selected after an exhausive evaluation may well give far superior performance than one chosen as a result of initial sales pressures only.

5.6 Deciding where to begin.

While all sectors or subsystems of the society should be considered in planning the system, one optimal place to start must be selected. This is not in conflict with the system approach. One governmental department may be readier than the others to start; one state or province may have more capable or more highly motivated people; or the education of one age group may be viewed by officials as having greater priority than the others. Careful evaluation of these capabilities, priorities, and opportunities, will indicate the best way to begin planning and

implementation of the system. Every alternative way to start should be viewed. Initial successes in early efforts will help build both credibility and a cadre of trained personnel that can later be used in planning and implementation of the entire national system.

5.7 Using research wisely.

Research on communications and instructional technology can have major political and social consequences as well as provide required technical information. Often maximal effectiveness can be obtained from minimal funding because of the high degree of motivation of those interested in conducting research and pilot projects. Below are a set of guidelines for the research and development which should precede decisions about national systems of the sort we have been discussing.

5.7.1 Determining the required research and development.

At the outset it is important to determine precisely what types and amounts of research and development data that are required before an informed decision can be made about a national system for communication and instruction. These requirements should be stated carefully, publicly, and widely. Failure to do this can lead to fragmented research and development efforts, waste of time and money, inconsequential research on "pet projects," or undue delays. A well planned research and development program can attract superior personnel.

In preparation for decision making involving all the personal, social, political, and other considerations outlined above in this chapter, a specific set of research and development activities should be planned and then carried out according to a precise research design with a definite schedule. The major steps in the procedure should be as follows:

(1) The entire range of potential system configurations should be reviewed, including various communications media and modes of instructional technology.

(2) The interrelationships among these prostheses and the living, human system that will use them should be spelled out.

(3) For each of these alternative systems cost-effectiveness estimates should be made as precisely as possible. The cost considerations described in Chapter IV should be basic to these estimates. The costs of each of the subsystems, classified by the methods described, in Chapter I, Chapter II, and pages 137 to 142 of Chapter IV, should be estimated. The total system costs should also be estimated. The categories of inputs which make up these costs should be broken down into matter-energy and information costs, living and nonliving. Particular attention should be paid to the human personnel inputs, classified by us as matter-energy inputs but also including information; monetary inputs, which are special sorts of information inputs; and time costs.

The costs for each subsystem or program and for the system as a whole should be broken down, as in Chapter IV, into fixed costs, variable costs, total costs, average or unit costs (i.e., units of education or communication services), marginal costs, capital costs, recurrent costs, noncurrent or start-up costs, opportunity costs, short-run costs, and long-run costs.

Each analysis should set up procedures whereby program budgeting could be done for the system. Also it should concern itself with such financial issues as the sources from which the necessary inputs or resources will come, the complexities of foreign exchange, and means of handling inflation.

(4) Estimates of the effectiveness or outputs of each subsystem or program and of each alternative total system should be made. In every case engineering effectiveness should be calculated first. Then estimated formative and summative evaluations of the effectiveness should be carried out, by the methods discussed in Chapter V. Effectiveness should be evaluated by tests of students before, during, and after training in units of cognitive, affective, attitudinal, and behavioral variables. Also it should be evaluated by measurements of the impact of students who have completed their training on the society, in terms of the cost-benefits in monetary units and the cost-effectiveness of changes in desired directions produced by the training on individuals in the society, and on organizations in it, and on the society itself.

(5) From all of these should be made technical recommendations based on the comparative cost-effectiveness of alternative systems. They should be ranked in order of preference.

(6) These technical recommendations should be reviewed by the ultimate decision makers of the country, who should also, in selecting the alternative to be implemented, take into consideration other related factors such as those discussed throughout this chapter.

5.7.2 Making maximal use of simulation.

In the early stages of research, development, and planning much can be learned by the use of computerized or other forms of simulation. Simple verbal or diagrammed descriptive models can be helpful in analyzing specific problems or alternatives. A tape recorder or a ground television station

can be used to simulate partially a satellite during a pilot study. Management decision-making games and simulations can be employed in training key personnel to make decisions. Simulation of the various subsystems of a total system and of the entire system itself can often reveal possible savings in cost and improvements in effectiveness, as well as point out operational processes which are likely to break down. When variables of the different subsystems and of the total system are simulated, rates of processes and their costs can be calculated. Such activity may demonstrate, for instance, that if the gross per capital product of a country is below a certain level it can afford only the simplest forms of instructional technology and only radio for communication. Simulations can also deal with such problems as the trade-offs between hardware and software which must be bought by capital investment--capital which is always in short supply in less developed countries--and labor intensive approaches which will accomplish the same purposes. Simulations can also reveal unemployment problems which may arise in the society if the labor of human beings is replaced by technology.

5.7.3 Knowing when to make a decision.

It is all too easy to continue research long beyond the time when it is needed just to postpone making a difficult decision. At some time as many data as practicable have been accumulated for the decision process. If the decision is not made at this time there will be continuing delays and frustrations. A longer wait invariably results in higher total costs, higher opportunity costs, and a longer wait for essential educational or other social development programs. Often an overly delayed decision may

result in major expenditures being made for alternative programs which then become increasingly competitive with a centrally planned system. Thus much of the advantage of such a system may be dissipated.

5.7.4 Using experimentation to build support.

Publicity, public support, and funding can all be built on the results of well defined and conducted pilot experiments, provided that their limitations are clearly recognized. One of the greatest difficulties is the fact that good programming is expensive, and seldom can be afforded in the amount necessary to conduct a really good pilot program. The pilot project thus could impede rather than advance the progress of the entire program unless this inherent limitation is clearly recognized and prepared for in advance. Wisely planned pilot studies, however, can build credibility, support, and staff for larger scale efforts to come.

5.8 Building internal communications.

Effective internal communications throughout the less developed country is vital in making a national communications system credible and acceptable. Those responsible for it should constantly ask such key questions as:

- Who needs to know (and also who would like to know) about it?
- What do they need to know?
- When do they need to know it?
- What medium is best for spreading this knowledge?

Though simple, these questions can form the basis for designing an internal communications program.

A uniquely helpful approach to this type of communications planning is provided by the Development Support Information Service of the United Nations Development Program. This organization has, for several years, addressed the problems in major development programs throughout the world which require communications with people at every level. It is a valuable source of ideas and assistance in planning communication and instructional programs.

5.9 Giving priority to programming.

Almost without exception, one of the most common failings in national communications systems for educational and other social development programs is undue emphasis on the hardware of the system and comparative neglect of the software. The message is more important than the medium, and it is essential to provide the necessary organization, personnel, and financial support to programming activities from the very earliest days of planning. The most successful programs are those which have given early high priority to the design of effective programming, letting its character govern the choice of system hardware rather than the reverse.

5.10 Proper support for operation and maintenance.

A second common failing of such national systems is an effort to save money by cutting or never providing adequate operations and maintenance budgets. This is dangerous, for a multimillion dollar system can cease to operate because of a lack of a critical part, or the inability of a maintenance man to find the cause for a breakdown. Maintenance and reliability must be designed into the system from the very beginning. Failure to do so will result in significant deterioration of system performance and decreased effectiveness.

5.11 Integrating monetary resources.

Overall integration and coordination of budgets from both local and foreign sources can be surprisingly effective in identifying, collecting, and making available the necessary resources for implementing a national communications system.

5.11.1 Consolidating internal resources.

Inasmuch as a national communications system will ordinarily serve a variety of agencies, the individual budgets of each of those agencies should be coordinated. The following questions must be asked of each agency: "What functions in your budget will be served by the system? Can this funding be diverted for implementation of that system?" Of course all the required money cannot possibly be obtained in this way because large expenditures are needed before any results are obtained which would eventually make monetary savings in agency budgets.

An effective way to obtain budgets for a national communication system is to project ahead for several years the proposed budgets for each agency responsible for social development programs and assume an increasing use by that agency of the communications system. Thus the normally expected increases in budgets of those agencies can often be restrained so that added money can be diverted to the centralized communication system.

5.11.2 Focusing foreign assistance.

Most foreign assistance sources are looking for a unique area where their aid can catalyze additional assistance from other sources. A careful analysis of the total foreign assistance requirements for a communications

system may demonstrate a logical role for each foreign assistance. Coordination with these agencies, both collectively and individually, will sometimes result in each one being pleased that their effort is part of an overall coordinated effort and thus being maximally efficient. Sometimes it may be impossible to avoid interagency competition.

5.12 Including a formal evaluation system.

The best possible initial system design will fall far short of the most effective possible one unless a procedure is incorporated into it for evaluation and revision of its structure and processes following implementation. Three key rules govern this design:

5.12.1 Content.

The evaluation system includes continual:

- Monitoring of ongoing activities
- Evaluation of them
- Feedback to originating organizations
- And revisions of procedures.

5.12.2 Organization.

The evaluation organization must be administratively separate from the implementing organization. Unless they are separate, though coordinated, the evaluating agency is always under undue constraint to approve and "whitewash" the results of the system as designed and implemented by the implementing agency. The freedom to be totally objective, rare in government, is essential.

5.12.3 Flexibility.

No matter how well designed initially, an evaluation system must be flexible and allow for significant changes in the evaluation procedures during the evaluation. Only thus can the evaluation improve as more is learned about the operation of the system.

6. Conclusion

The many practical considerations in this chapter, highlighted by the 12 steps listed immediately above, will hopefully provide guidelines and assistance to less developed countries in choosing, planning, and implementing national and instructional communication systems for effectively implementing educational and other social development programs. The methodology for the difficult task of deciding among alternative systems has not yet matured. Nevertheless, a widespread consensus is arising about its essential characteristics.

CHAPTER VI

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