PN-ABE-034
64184

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INFORMATION AND TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES

by

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Presented at the 51st General Conference of the International Federation of Library Associations and Institutions (IFLA), Palmer House, Chicago, Ill., August 20, 1985

(Abstract)

Information and Technology Transfer

To Developing Countries

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The technology transfer process involves the movement of three elements: information, know-how, and "hardware" - the physical embodiment of a device that is used to do work or to provide a service. Each element has different properties and is transferred using distinct methodologies that have unique information requirements.

Several flow charts illustrate the complexity of the technology transfer process, but major emphasis in the paper is placed on the key role of information in the problem-solving process, of which technology transfer is a special case.

The five basic action steps used in problem solving and technology transfer are Diagnosis, Design of Problem Solution Strategy, Acquisition of Information, Analysis of Information, and Adaptation and Application of Information to solve the problem or transfer the technology. Each step is discussed briefly and the danger of sub-optimization of information acquisition beyond available human capabilities to analyze and apply it is stressed.

Information and Technology Transfer to Developing Countries

INTRODUCTION

The United States Agency for International Development (AID) has operational responsibility for implementing the U.S. development assistance program in over 70 countries. To focus AID's efforts, its administrator, Mr. Peter McPherson, has identified four key development pillars: 1) encouragement of sound host country economic and social policies at all levels -- macroeconomic, sectoral, and microeconomic; 2) emphasis on the private sector to support the growth of productive, self-sustaining, income- and job-producing private sectors in developing countries; 3) fostering institution building to enhance countries' abilities to marshall human and financial resources to ensure that development will continue long after assistance ends; and 4) promoting the creation, transfer and adaptation of technology and assisting countries to become capable of developing and applying a continuous stream of innovations that increase productivity, employment, and incomes.(1)

The cutting edge of AID's technology development and transfer activities is the Bureau for Science and Technology. Within it is the Office of Health whose Division of Water Supply and Sanitation sponsors the WASH Project -- Water and Sanitation for Health. The WASH contract operation provides AID's Bureaus and 73 overseas Missions and Offices with a broad range of short-term technical assistance services, including information support from its specialized library. Since 1980, the library's micro-computerized catalog has grown to 4,000 documents and additionally includes 80 country boxes of country-specific water supply, sanitation and environmental health related reports, maps, data, etc. The WASH Operations Center serves as AID's focal point for quick response support to AID Missions, disaster situations, local host country governments, private voluntary organizations, U.S. agencies, and organizations in the AID-assisted developing countries. WASH also collaborates with international organizations and is an active participant in the United Nation's International Drinking Water Supply and Sanitation Decade (1981-1990).

In support of AID's development pillars, one of WASH's major functions is the transfer of technology. The details of this complicated process cannot be

expounded upon in this paper; rather we will explore the role of information transfer as a key element in technology transfer, considered generically as a problem-solving process. But first we must consider what is meant by the term "technology."

Four Categories of Technology

Jacques Ellul, the contemporary French professor of law, theologian and philosopher-critic, has written extensively on the impact technology has on the western world. In his recent book, The Technological System, he states that

> "the entire field of activity, of human life, is the object of technologies. According to their application areas, we can divide these technologies into: mechanical technologies (a very wide term, also covering things that are not, strictly speaking, mechanical, like computers); economic technologies (for research and intervention); organizational technologies (for all types of social organisms, including government, administration, etc.); and 'human' technologies (for the individual or for noninstitutionalized groups, advertising, propaganda, group dynamics, psychoanalysis, etc.)."(2)

From Professor Ellul's view, we can see that "technology" is not a homogeneous concept. It really has ~~has~~ three major components: hardware, information, and know-how. Ellul's "mechanical technologies" include hardware; his other three categories of technology include only information and know-how. They are intimately related and all three are necessary for any technology to be designed, made, installed, used, maintained, or transferred. Hardware is the physical embodiment of a tool, device, material, part, or system that is used to do work or to provide a service. Information is written, verbal, or graphic descriptions, designs, specifications, procedures, and methods about all aspects of making, using, maintaining, operating, training, financing, and administering technology. Know-how is the skilled use of information and interpersonal relations to identify and solve problems. Know-how combines hardware and software (information) to produce desired technical solutions.

A Definition of Technology Transfer

Given these diverse categories of technology, it is not surprising that transfer modes should be, and are, equally diverse. For the purposes of this

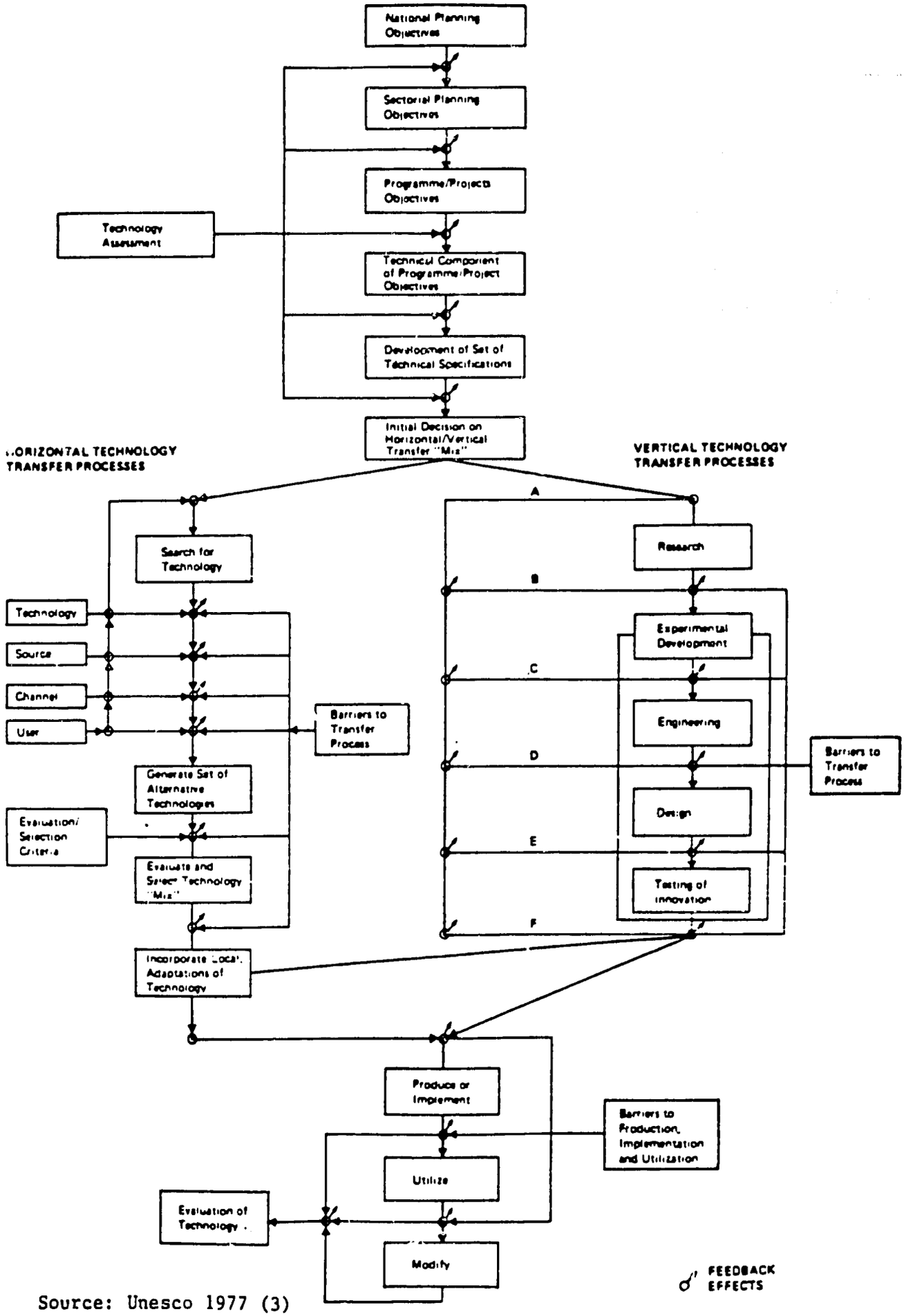
paper, it should be sufficient to consider "technology transfer" as the movement and use of a given technology, with or without adaptation, from one institutional or organizational setting to another. It may be from a laboratory to a manufacturing unit, from farm to farm, office to office, or from one country to another. While technology transfer at first may appear conceptually simple and straightforward, in practice, even within a single organization, it is often a lengthy, complex, and sometimes unsuccessful process.

The Complexity of the Technology Transfer Process

The following three charts illustrate this complexity. Each step, block or cell on the charts have a different set of information requirements. This fact is often unrecognized or ignored with devastating consequences. The first chart is from a Unesco development study for the Arab States, and illustrates the "Interrelationships Between Horizontal and Vertical Technology Transfers and the National Planning process." The second chart is from the WASH Project of AID and lists the "Sequence for Technology Transfer Phases in Manufacturing and Marketing Water and Sanitation Devices in Developing Countries." Notice the important role that "software" plays in the sequence, software referring to the information and know-how aspects of technology. The third chart, also from WASH, identifies the major tasks and the task-execution responsibility of those concerned with the transfer and utilization of technology at the R&D, factory, and village levels in developing countries. It incorporates some features of the previous charts.

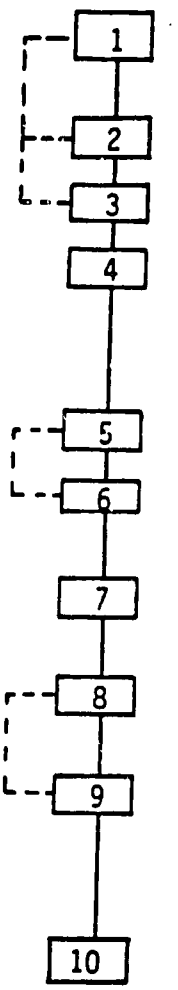
The charts show the various steps necessary to implement technology transfer at all levels -- from policy, planning, and conceptualization through research and development or acquisition to operational management of the transfer process and final utilization of the technology in production or in application by users or consumers. It has been emphasized that each step and each box in the charts has distinct information requirements, and each can be regarded as a separate, but related, information problem. The remainder of this paper will discuss the role of information in the problem-solving process, of which technology transfer is a special case.

Chart 1. Interrelationships Between Horizontal and Vertical Technology Transfers and the National Planning Process



Source: Unesco 1977 (3)

Chart 2. Sequence For Technology Transfer Phases In Manufacturing and Marketing Water and Sanitation Devices In Developing Countries



1. Concept of device to satisfy existing need
2. Working or lab models
3. Production prototypes
4. Software preparation for field testing: organization, finance, community education and participation, logistics, marketing planning, etc.
5. Field testing of hardware and software
6. Modification of hardware and software and retesting as required
7. Preparation for first stage introductory production and marketing
8. First stage production and marketing
9. Evaluation of first stage introductory operations and their modification for second stage production and marketing
10. Second stage production and marketing

Solid lines are action flows
Dotted lines are illustrative information feedback flows to improve iterative actions

Phases may overlap in time

Source: WASH Project (AID) (1984) (4)

Chart 3. TECHNOLOGY TRANSFER AND UTILIZATION MATRIX

MAJOR TASKS	TASK EXECUTION RESPONSIBILITY										
	AID	WASH		PVO	Government			Local Business	Village/ Community	Other	Remarks
		Staff	Cons		Natl	Reg	Local				
1. Need/Demand Assessment for WS&S Systems/Services											
2. Technology/System Selection											
3. Sourcing of Technology											
3.1. R&D											
3.2. Purchase											
3.3. Local Mfg.											
3.4. Field Fabrication											
3.5. Logistics											
4. Village Operations											
4.1. Organization											
4.2. Supply											
4.3 Training											
4.4. Fabrication											
4.5. Installation											
4.6. O & M											
4.7. Evaluation											
5. Planning											
5.1. Overall Program/ Project Design											
5.2. Organization of Participants and Role Assignments											
5.3. Detailed Planning of Above 4 Phases											
5.4. Financial Planning											
5.5. Scheduling											
5.6. Evaluation Planning											
6. Evaluation											

Source: WASH Project (AID) (5)

The Role of Information in the Problem-Solving Process

1. The critical role of information in the problem solving process is illustrated in the diagram on the following page which includes six elements - the problem situation itself and five action steps:

   1. Diagnosis of Problem
   2. Design of Problem Solution Strategy
   3. Acquisition of Information
   4. Analysis of Information
   5. Adaptation and Application of Information

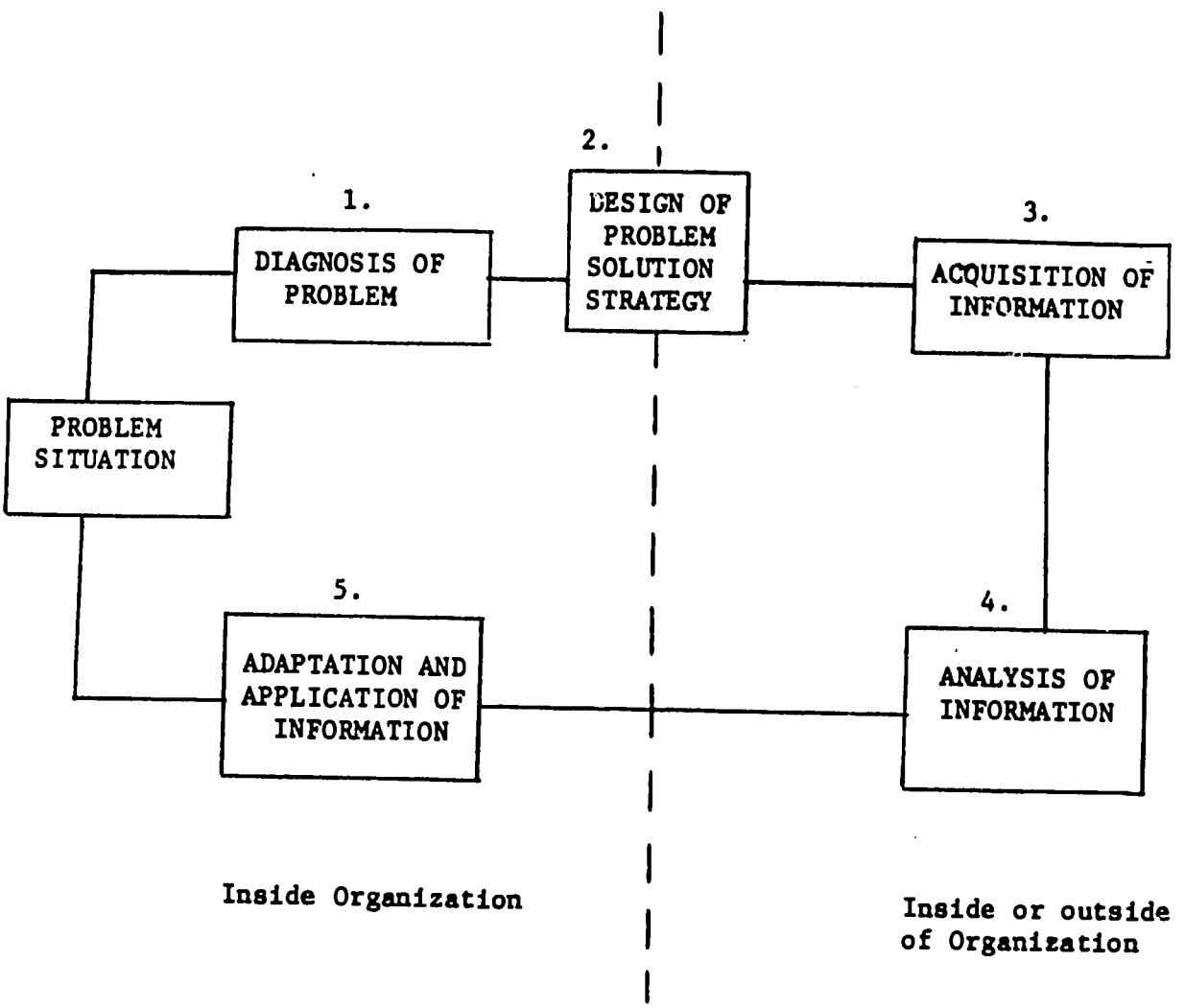
   Note: each of the five action steps in this chart apply to every block, phase and cell in the other charts on the technology transfer process.

2. The line which connects the six elements indicates the flow of problem-solving information in both directions on an iterative basis as required until the problem is solved. The vertical line indicates a possible organizational boundary. Depending on the size, staffing, and resources of an organization, the five action steps may take place within the organization, or steps 2, 3, and 4 may be executed outside the organization through the use of consultants, advisory services, data banks, etc. Action steps 1 (Diagnosis) and 5 (Adaptation and application of information) must take place within the organizational problem situation context.

3. The sequence of action from diagnosis through adaptation and application of information to resolve a given problem situation requires different skills ("know-how") and involves different types of information in each step.

4. The correct diagnosis of a problem is the key element in the sequence. If the diagnosis is incorrect, all subsequent actions are irrelevant and wasted. You may have answers, but they won't help solve the problem at hand.

Chart 4. ROLE OF INFORMATION IN THE PROBLEM SOLVING PROCESS



Solid line indicates flow of information in both directions.

5. The development of diagnostic problem-solving skills requires education, training, and experience ("know-how") at all organizational levels -- mechanics, clerks, supervisors, managers, and policy-makers. And at each level and for each problem, the diagnostician brings a distinct store of knowledge (information) to bear on the situation. It should be noted that the kind of information needed to properly diagnose a problem situation may be quite different from the kind of information needed to design a problem solution strategy.

6. Once the problem has been clearly identified in its situational context, one proceeds to Step 2: Design of Problem Solution Strategy. This step generates alternative approaches to information acquisition and to solving the problem consistent with the overall problem situation -- objectives, resource availabilities, constraints, time-frames, assumptions, etc.

7. In the course of designing the problem solution strategy, it may be necessary to reconsider the diagnosis and to reappraise the problem, as well as the situation, which may have changed. Such a reiteration may be required several times before the final strategy is determined, as indicated by the bi-directional flow of information in the diagram.

8. The person who designs the problem solution strategy may or may not be the same one who did the diagnosis and may or may not be inside the organization having the problem. And he depends on a different set of skills and information than the diagnostician. He must know <u>how</u> to solve the problem; <u>what</u> solutions are relevant, feasible, and appropriate; <u>what</u> specific information is required; <u>where</u> to go for it; and <u>how</u> to get it. After all, you do not want to suggest searching for an $800,000 process if only $100,000 is available for investment, or to encourage methods for manufacturing a $5.00 product when the competitive price is $2.00. This step also identifies, directly or indirectly, the informational needs. This brings us to Step 3: Acquisition of Information.

9. Large organizations often have the information required to solve a specific problem available from their own files, records, drawings,

catalogs, data banks, patents, libraries, or information centers. Smaller organizations may have a few directories, catalogs, abstract journals, indexes and technical journals, along with a small collection of documents related to their field of work. While these may or may not contain a solution to the problem, they may provide an indication as to where such information may be, what form it is in, who has it, and who could be contacted to acquire it. The smallest organizations (and countries) often must go outside to acquire the information they need to solve their problems.

10. Given the exponential growth of scientific and technical information (STI) over recent decades, a large number of abstract and index journals have come into being in all fields of S&T to assist in locating potentially useful information. Many of these journals are available in microform (micro-fiche and micro-film) and computer tape form besides their usual paper format. In addition, specialized services ("data banks") now have available, via telecommunication channels, literally millions of references, titles, and abstracts of STI. Europe, North America, South America, Asia, and the Near East are now linked by cable, satellite, micro-wave, and land lines to make the acquisition of STI an instantaneous reality by telephone, telex, modem, and/or video terminal at your desk.

11. As powerful and complete as many such systems are, for many organizations they create their own kind of special problem -- they make the acquisition of STI too easy and too quick (albeit not too cheap). What happens is that too much information is acquired -- more information than can be properly <u>analyzed</u> in relation to the capabilities and problem at hand. A good librarian in a fair sized information center, with or without access to a "data bank," can generate more STI material than can be digested and analyzed by a competent engineer, economist, or agronomist in a reasonable length of time.

12. This takes us back to the design of the problem solution strategy. If the information requested to solve the problem is not specific or precise, if it is general or vague, it may cause the acquisition of an excess of

information. Rather than having only twenty abstracts or reports to analyze, a poorly phrased question may generate fifty or one hundred and fifty documents. If the wrong problem was diagnosed in the first place, you can see how wasteful and confusing the process can become.

13. There are two lessons here: first, to be very careful in the diagnosis and the design of the problem solution strategy and the phrasing of the information request; and second, to avoid over-loading the analytical capacities of the individuals and organizations concerned.

14. Which brings us to the last action step in the problem solving sequence: adaptation and application of information to resolve the problem situation. This requires a special and relatively rare set of skills ("know-how"). The prior steps of information acquisition and analysis can be considered "academic" or "theoretical" because they only involve dealing with words and concepts separated from the reality of the problem situation. The adaptation and application step is pragmatic in that it attempts to put information to work in the field, in the face of a specific problem, and tries to solve that problem. In the application of information, we relate and connect information with reality. The quality, relevance, and completeness of the solution cannot be better than the information supplied and the skills of the person who uses it.

15. To summarize the problem solving sequence illustrated above: Step I, Diagnosis, involves perception and cognition of the operational realities of a given problem and its context. Step 2, Design of Problem Solution Strategy, generates alternative approaches to solving the problem. This step also identifies the kinds of information needed to solve a problem or on which to base decisions. Step 3, Information Acquisition, can be straightforward and direct, or may involve the use of data banks and extensive literature and patent searches. Step 4, Information Analysis, is as simple or as complex as the problem situation, and the content and scope of the information (solutions) assembled. The Adaptation and Application of Information, Step 5, evaluates and fits the proper alternative or data to the realities of the problem situation, and creates the synthesis and solution desired. It is significant to note

that Steps 1 and 5 require intimate, first-hand knowledge of the problem situation. Step 5 must be implemented within the problem situation or the organizational context that generated the problem. Steps 3 and 4, on the other hand, can be considered as "second order abstractions" and can be implemented anywhere, either inside or outside of the organization, depending on the availability of resources, qualified personnel, and communication linkages.

16. The information flows involved in the problem solving sequence present very real dangers of sub-optimization within the information system. Given the rapidly expanding volume of scientific and technical information, which is being paralleled by the development of large scale data banks and automated information retrieval and dissemination services, it is now relatively easy to drown people in a flood of information. More information can be acquired than can be properly analyzed and effectively applied. The trap of sub-optimization of information acquisition (Step 3) must be avoided, since the basic objective of information systems is to solve problems by applying (Step 5) the appropriate information derived from the analysis (Step 4).

17. A final observation: The effective and proper use of information is neither simple, nor obvious, nor widely practiced. Good information is necessary for sound decision making. But, if the decision-making process itself is not well organized and understood by all concerned, even the best information will not be able to play its vital problem solving role.

To summarize, we may say that the technology transfer process includes three kinds of transfer problems:

- transfer of information,
- transfer of know-how, and
- transfer of hardware.

Each transfer problem has a different content and requires different methodologies that must be carefully integrated in the overall process. Technology transfer begins with the acquisition and transfer of information, either from the supply (production) side, or from the demand (user or market)

side. The transfer of know-how, skills, and application information is necessary to establish production, marketing, utilization, and oroblem-solving capability in the individuals and institutions in the receiving country. Transfer of know-how is also necessary to create understanding, acceptance, motivation and effective operation and maintenance capability in the users of the hardware. Information and know-how are then used to adapt, transfer, make, market, use and maintain the hardware in completing the technology transfer process. Information and know-how can be considered the software side of the technology transfer equation with hardware on the other side. Both sides must be carefully coordinated and integrated if the technology transfer is to be successful over the long-term life-cycle of the hardware, institutions, and markets involved.

The Chinese have a proverb that provides a fitting close to this discussion:

> If you are planning for a year, sow rice,
> If you are planning for a decade, plant trees,
> If you are planning for a lifetime, educate a person.

It is hoped that this paper will contribute to education in the complex process of transferring information, know-how and technology to developing countries.

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