Technology Transfer – Successes and Failures

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Abstract – *During the last four decades there has been considerable international activity in technology transfer across national and continental boundaries. Numerous international and philanthropic agencies have supported the exchange of technology between industrially developed and developing countries. There are many examples of successful projects, that have fostered the need to expand these efforts. There are also notable failures, when projects conceived with good intentions have failed due to one or more of a set of complex reasons. The lessons learnt from these experiences emphasize the need to be cognizant of a variety of socio-economic, geo-political and historical / cultural factors, in addition to the technical aspects that are necessary for successful technology transfer.*

Technology is knowledge or the state of knowing through study or experience. Technology transfer is the transfer of knowledge, knowledge that can be stored, and conveyed in many ways: such as written work, the spoken word, and computerized data banks. Within this context, the term transfer means use of technology. For example, the fact that a book is written does not mean that its contents have been or will be read. If the book's contents are read, it does not mean that the author's words are understood. If the words were understood, it does not mean that knowledge has been transferred unless and until that knowledge has been applied or used. Thus, the transfer process requires that the technical knowledge has been put to use. The success or failure of its use does not determine the state of transfer, its use does.

There are two major modes of technology transfer, passive and active. These modes refer to the transferring agency's role in solving the user's problem. In the passive mode, the transfer agent presents the technical information as written or spoken data, and the user is left alone to decide how he or she will apply the knowledge to the problem. Here the user has not been helped.

One most familiar and widely used form of passive technology transfer is the 'cookbook' (or self-teaching manuals, or how-to-do guides). This mode presumes an elementary familiarity with, and competence in, the subject. An important element missing in the passive mode is the skill learned by hands-on practice obtained under instruction.

In the active mode of technology transfer, the transferring agent informs the potential user on how to apply technology, or shows its applicability to the

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perceived need. The technology transfer agent plays a key role. He or she puts on the problem solver's mantle and approaches the problem of a non-technologist with the hope of applying existing technology to the solution of an important problem. The agent gets involved in accurately enunciating the problem. The technology transfer agent must listen carefully to the problem, restate the problem in such terms as to simplify search for available technology. Sometimes it may turn out that the original statement of the problem did not state the real problem. The next step is to retrieve pertinent technology. It may be done by specialists under the agent's directions. The agent actively searches for the solution to the problem.

There are six elements in the technology transfer process that merit consideration. These elements include:

- A precise statement of user need;
- Acceptable solutions that are clearly stated and understood;
- A firm commitment by the user to stay actively associated during and after the transfer;
- Involvement of a manufacturer at an early stage;
- A market analysis;
- A champion and an entrepreneur.

A brief description of these elements and their importance to technology transfer follows:

USER NEED

There must be a mutually agreed upon statement of the need or problem to provide a stationary target for the technologist's aim. Interim changes in the definition of need can only serve to bring into question the need, and the credibility of the user becomes questionable. Approaches to the solution can change during the solving of the problem, but never the need. Also, a common pitfall, namely, 'finding solutions to problems that do not exist' should be avoided.

ACCEPTABLE SOLUTIONS

Although solutions to a problem can vary anywhere between zero and infinity, the range of solutions acceptable to the ultimate user are usually found in a very narrow band. The user and technologist must be clear on the implications of technical aspects of solutions and the expectations of the user. The user sets the boundary of acceptable solutions. While the user may not have a good appreciation of the technical complexities, there should be a clear understanding of the kinds of acceptable solutions. The development of the end product is chiefly the responsibility of the technologist.

EVOLUTION OF TRANSFER PROCESS

The user and technologist should stay flexible in their thinking as the transfer process evolves. Active association of the user with the process is necessary, especially if any redirection of the project becomes necessary. Then, the user must help in redefinition of the acceptable boundaries.

INVOLVEMENT OF MANUFACTURER

Involvement of a manufacturer at an early stage in the transfer process is often important to the success of technology transfer. This allows the manufacturer to become familiar with the project's development so that he or she becomes prepared for the final production activity in good time. A manufacturer is motivated to join the team for increased profits, knowledge of where innovative ideas could make current products obsolete, timing, and if a product can be marketed less expensively than its competitors.

MARKET ANALYSIS

A lack of appreciation and basic understanding of the market place has led to more failures in technology transfer. A technological solution must not only be a technical success, but also a market success. The importance of this statement is often not perceived by the technologists. For example, if the solution involves an unacceptable or unavailable capital investment, of what use is the solution? If on the other hand, the solution represents only a marginal improvement of what is currently available to the user at a lower cost, then why should the user switch?

An early market analysis can make a significant contribution to the identification of not only the manufacturer, but the motivation factors involved. This is useful in the development of new products and processes which are risky in business and call for an investment of resources. This is particularly true in the transfer of advanced and sophisticated technologies.

MOTIVATOR/CHAMPION

The presence of a motivator or a champion is essential to keep the project moving to the ultimate goal. This

individual makes the necessary adjustments to make certain that the project keeps heading in the right direction. Without the champion, people tend to lose their enthusiasm, the budget tends to overrun, schedules tend to slip, projects either die or continue indefinitely, seeking ever changing goals.

Successful technology transfer involves a combination of several mechanisms. Already developed technology may be bought or licensed as patents, products or know-how packages. This is perhaps the easiest mechanism of technology transfer, however, it requires that the information transferred is complete and the user can continue to use the technology without any help from the supplier over the duration of the project. Specialized machinery embodying needed technologies may also be directly bought. This is especially useful when the user is short of resources to build the needed equipment at location.

Foreign experts are often used as technology transfer agents. Many successful programs have involved setting up links between educational institutions from host and foreign countries. Networks of research scientists and extension agents have led to many long term developmental programs on focussed issues. During the mid-1970s, the United Nations promoted the use of scientists born in developing countries but settled in industrialized nations to return to countries of their origin and serve for short durations as technology transfer agents. Experience with this scheme has shown that these individuals often have a better appreciation of the peripheral factors such as cultural and social, that may have a serious impact on the outcome of a given project.

Multinational corporations play a major role in technology transfer by establishing industrial enterprises in developing countries. The manufacturing and management practices followed in these establishments are often similar to those followed in industrialized countries. The work force from the host country is often used and the manufacturing techniques are effectively transferred to local staff.

Personnel from developing countries are often trained in industrialized nations to learn modern practices associated with a given technology. Although some personnel sent abroad may emigrate, special types of visa restrictions often encourage individuals to return to their country of origin and contribute to its development. A more serious problem happens when the individual's training is in areas far removed from the needs of the developing nation. Carefully designed training programs can help alleviate these problems.

Establishment of public institutions in developing countries involving education, research and development, and extension services have contributed immensely to technology transfer during the last four decades. For example, the role of the International Rice Research Institute (IRRI) and International Center for Corn and Wheat Improvement in bringing about what is generally known as the 'green revolution' in many developing countries is noteworthy. In addition, specialized centers have been established for technology transfer mainly for the training of personnel (used effectively in Taiwan and Mexico).

The governments of developing countries must play a major role in maintaining a suitable economic and social climate for innovation and change, as done recently by Korea and Taiwan. Special cells within these governments are charged to assure the success of technology transfer. The rapid development of various industrial sectors in Taiwan and Korea is partly because of their governments' strong and unequivocal commitment to the transfer of technology from other industrialized nations.

Experience has often shown that there are several obstacles to technology transfer. These obstacles should be considered in the beginning and steps taken to overcome them. It is well known that there is a universal resistance to change. There are restrictive patent and trade policies that must be overcome in certain instances. Other potential barriers include:

- Inadequate skills in the entire work force from management staff to semi-skilled labour.
- Inadequate physical, social and economic infrastructure. Although within the local culture the infrastructure may be quite adequate, the changes brought by the new technology may lead to the inadequacy of the existing structure.
- Often, there is limited knowledge of local resources such as water, raw materials or other needed resources.
- The local economy may be without capital and the incentives for investment may be lacking.
- In many developing countries resource ownership is often limited to a minute sector of the population. This may raise ethical questions on the sphere of impact of the transferred technology.
- The mobility of labour is often limited in developing countries. This increases the reliance on inadequate or limited supply of work force.
- Advanced industrial nations normally develop technologies that trade off large amounts of capital to reduce labour requirements. Such technologies may not be appropriate to conditions found in developing countries where increased employment is often an important issue.

The previously mentioned barriers can be overcome to a certain extent by **the establishment of independent, goal-oriented applied research institutions.** The

primary task of these R and D institutions is not the transfer of a specific scientific or technical development into a field of application, but for the development of a multi-disciplinary capability to act as an agent to absorb, change, and diffuse technologies and innovations from both external and internal sources. Such R and D organisations should be considered as vehicles to foster appropriate technology transfer concepts. In the early development of such institutions, highly original research would play a role secondary to these functions. The institutions should be field-oriented and organized in such a manner as to ensure the necessary contact between the scientists and the consumers of the given technology. Applied research institutions, if they will function, must rely almost entirely on the ability and skills of their staff to deal with the real problems of the developing society. These institutes can be charged with the responsibility to define the problems and the needs of its clients. Its staff can search out the suitable technologies, screen them for appropriateness, and change them and test them for local conditions. If associated with agricultural, industrial or medical extension services, they could also participate in diffusion of these modified technologies. Hence, R and D institutes could fulfil several of these functions which are important to technology transfer.

If one examines the role of goal-oriented R and D institutes in the context of the special obstacles in developing countries, an opportunity to overcome these barriers can be seen. The institutes can:

- Participate in training needed personnel,
- Provide a two-way channel for the interchange of ideas and information from government ministries and the consumer,
- Supply new information on local conditions and needs to foreign agencies and economic groups interested in advancing the economy of that country or interested in establishing commercial enterprises or joint ventures,
- In the long-range, reduce the dependence of the developing countries upon a continued supply of technology from foreign countries.

None of these benefits can accrue automatically. There is always a grave danger that the R and D staff will involve itself in academic activities consonant to their training in Western universities and become a drain on scarce capital and human resources. This seems to be the case with many R and D institutions in developing countries which have contributed little to improving technology of local industry and agriculture.

In many countries, development is not constrained by lack of advanced knowledge, but in the organization of that knowledge into a useful form so that it is adapted to local conditions and forms a basis for technological development. The R and D institutes can contribute only if they are properly structured, oriented, and motivated for this purpose.

The role played by international institutes such as IRRI in diffusing advanced agricultural technology may well serve as a model for the development of similar institutes aimed at diffusing advanced medical technology in the developing countries. As the sophistication of medical procedures and equipment increase, it becomes vital that proper mechanisms are developed so that the scientific advances are within the reach of a larger segment of the population. The fabrication and maintenance of modern instruments used in the application of advanced technology require the careful development of an infrastructure that can provide adequate support for needed services. Such issues can be effectively considered by the proposed international institutes.

In summary, technology transfer, or the use of knowledge through experience, can be effectively realized when its important elements are carefully considered. There has been an exponential growth in the development of new technology during the last fifty years. Most of these developments have been limited to a few industrialized nations. In the future, more programs involving technology transfer will become necessary to share advances in the fields of science and engineering with the broader segments of population especially in the developing regions of the world.

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"A physician may possess the science of Harvey and the art of Sydenham, and yet there may be lacking in him those finer qualities of heart and head which count for so much in life ... Medicine is seen at its best in men ... of the highest and most harmonious culture".

Osler W. *Address to Members of the Medical Profession,* 1895.