Technology Transfer Issues and a New Technology Transfer Model

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The following are major issues that should be considered for efficient and effective technology transfer: conceptions of technology, technological activity and transfer, communication channels, factors affecting transfer, and models of transfer. In particular, a well-developed model of technology transfer could be used as a framework for facilitating a technology transfer process. There are many popular models of technology transfer; examples include the appropriability model, the dissemination model, the knowledge utilization model, the contextual collaboration model, the material transfer model, the design transfer model, and the capacity transfer model (Rogers, 2003; Ruttan & Hayami, 1973; Sung & Gibson, 2005; Tenkasi & Mohrman, 1995). According to the appropriability model, purposive attempts to transfer technologies are unnecessary, because good technologies sell themselves. Regarding the dissemination model, the perspective is that transfer processes can be successful when experts transfer specialized knowledge to a willing recipient. The knowledge utilization model emphasizes strategies that effectively deliver knowledge to the recipients. A contextual collaboration model is based on the constructivist idea that knowledge cannot be simply transmitted, but it should be subjectively constructed by its recipients. The material transfer model focuses on the simple transfer of new materials, such as machinery, seeds, tools, and the techniques associated with the use of the materials. According to the design transfer model, transfer of designs, such as blueprints and tooling specifications, should accompany the technology itself for effective technology transfer. The capacity transfer model emphasizes the transfer of knowledge, which provides recipients with the capability to design and produce a new technology on their own.

These models were developed and used to make technology transfer successful. A successful transfer of technology, however, might not be guaranteed simply by using a particular model. In addition, the previously mentioned models of technology transfer tend to be fragmented rather than integrated. This implies that a new model of technology transfer should be developed that includes novel and macro viewpoints. Accordingly, this article will propose a new integrated model of technology transfer that reflects recipients' perspectives by considering the key components for enhancing technology transfer. In order to achieve this purpose, this paper first focused on understanding implications that are necessary to identifying the main components for effective technology transfer by reviewing and analyzing the main issues related to technology transfer.

Technology Concepts, Technological Activity, and Technology Transfer

Defining technology is paramount because it helps to identify phenomena related to technology transfer. Since the 1960s, many scholars have tried to understand the real meaning of technology using different underlying philosophies (DeVore, 1987; Frey, 1987; Galbraith, 1967; Mitcham, 1980; Skolimowski, 1966). The definitions or meanings of technology these authors proposed were unique, according to their context, philosophy, economy, or other variables. This implies that it might not be that simple to define technology because technology is situation and value specific. However, the concept of technology should be outlined in order to understand what is being transferred in a technology transfer process. Two approaches have been used to comprehend technology: one is to define technology in a way of capturing the platonic essence in a few sentences by differentiating technology from science, and the other is to provide characterizations of technology. Scholars, such as Skolimowski (1966), Galbraith (1967), and DeVore (1987) might be the representatives of the former approach. Skolimowski (1966) defined technology as a form of human knowledge and a process of creating new realities. He argued that science is concerned with what is, but technology is concerned with what is to be. Later, Galbraith (1967) defined technology as the systematic application of scientific or other organized knowledge to practical tasks. This definition is notable because it emphasizes the systematic and practical aspects of technology. DeVore (1987), a major scholar, made an effort to define technology. He argued that technology should create the human capacity to "do," and it should be used to create new and useful

products, devices, machines, or systems. He also emphasized the relationship between technology and social purpose. He contended that technology has always been situated directly in the social milieu and conditioned by values, attitudes, and economic factors; thus, the goal of technology is the pursuit of knowledge and know-how for specific social ends.

In contrast, some scholars criticized defining technology in a few sentences. They argued for providing characterizations of technology. Frey (1987) could be considered the most typical advocator of this approach. In 1987, he characterized technology as four elements: object, process, knowledge, and volition. Technology as object is regarded as the concept of physical embodiments, involving tools, machines, consumer products, instruments, or any objects that have intentionally been created to extend practical human possibilities. Moreover, technology as an object may be tangible and focused on efficiency. Technology as process is concerned with how to use or develop the object effectively. From the systems perspective, technology as process would be a means to improve the system's performance. Skolimowski (1966) also supported this knowledge viewpoint when he stated that technology is a form of human knowledge. According to Mitcham (1980), volition, which incorporates aims, intentions, desires, and choices, provides links to tie together the three aspects of technology: object, process, and knowledge. All technologies are influenced by human intention. In other words, when, how, and why technology will be used depends on human intention and will. Consequently, technology as volition emphasizes the human element and culture within technology.

According to DeVore (1987), the range of technological activity includes everything from problem identification to the design and implementation of solutions. This involves not only technical or physical elements but also human elements. Savage and Skerry (1990) argued that the ultimate outcome of technological activity is the solution derived from the problem-solving activity undertaken by humans through the use of technological processes and resources. The model of technology activity that Johnson, Gatz, and Hicks (1997) proposed seems to be based on the open-systems model composed of inputs, transformations, outputs, environment, and feedback. Their model consists of inputs, personal problem solving environment, outputs, and impacts of social context. They regarded the ultimate outcome of a technology activity as the extension of human capabilities through the creation of artifact, knowledge, and process. This view is very important because it implies that technology can be used to improve both system and individual performance; thus, it can be a tool for Human Resource Development (HRD) interventions.

Markert's (1993) definition of technology transfer is the most typical - she defined technology transfer as the development of a technology in one setting that is then transferred for use in another setting. However, this definition does not reflect a deep comprehension of technology transfer, because it is mostly focused on differentiating technology development from utilization. To overcome the disadvantage of this definition, Johnson, Gatz, and Hicks (1997) tried to interpret technology transfer through a holistic perspective that included both the movement of technology from the site of origin to the site of use and issues concerning the ultimate acceptance and use of the technology by the end user. They argued that recognizing the end user's needs and the context where the technology will be used is essential for the successful transfer of technology. Technology transfer is not the same process and perception for everybody. Universities, corporations, federal labs, and developing countries have different roles and interests in technology transfer. For example, universities, as a provider of technology, view technology transfer as a means for serving a community through knowledge sharing. On the other hand, technology transfer is regarded as a way to obtain competitive advantages through performance improvements in corporations that are the recipients of this technology. Like this, the perception of technology transfer in each site would be different. According to Frey (1987), technology can be an object, a process, or knowledge that is created by human intention. In most cases, technology tends to be the integration of all three components: object, process, and knowledge. Therefore, a provider of technology should try to transfer the integration of all components that make up that technology, not just one component.

Diffusion of Technology Innovations

According to Rogers (2003), diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system and by which alteration occurs in the structure and function of a

social system as a kind of social change. Diffusion is an extremely critical process for the practical use of innovation and reinvention. In other words, diffusion plays a pivotal role in helping the adopters fully take advantage of an innovation and to modify that innovation. Thus, the comprehension of the major issues in the diffusion process is essential for making technology transfer successful.

Diffusion consists of four key elements: innovation, communication channels, time, and a social system (Mahajan & Peterson, 1985; Rogers, 2003). The issues of diffusion can be analyzed based on the main elements in the diffusion. According to Rogers (2003), innovations have five common characteristics that help to explain the rates of adoption; these can be relative advantage, compatibility, complexity, trialability, and observability. He argued that the greater relative advantage, compatibility, trialability, and observability and the less complex the perceptions of an innovation are, the faster the rate of adoption. Change agents need to use this implication to speed up the rate of diffusion and to make the potential adopters recognize the need for change.

In the diffusion process of innovations, the information exchange occurs through a variety of communication channels, such as mass media, interpersonal channels, or interactive communication (e.g., via the Internet). More effective communication occurs when two or more individuals are similar (i.e., homophilous). However, some degree of heterophily, the degree to which two or more individuals who interact are different in certain attributes, is usually present in communication about innovations (Rogers, 2003). It is important for change agents or HRD professionals to recognize these heterophilous aspects in order to enhance a mutual understanding for the innovation.

Diffusion occurs within a social system, and the social system constitutes a boundary within which an innovation is diffused (Mahajan & Peterson, 1985; Rogers, 2003). The social system has structure, giving stability and regularity to individual behavior in a system (e.g., as norms). The social structure of a system can facilitate or impede the diffusion of innovations in the system. For example, it might be very difficult for Catholic countries to adopt a new medical method for abortion. People whose religion is Catholic regard abortion as one of the biggest sins. Thus, the norm in Catholic countries would be reluctance to acknowledge abortion-on-demand. Consequently, the social structure of Catholic countries might impede the diffusion of a new medical method for abortion. In addition, the social system can influence the types of innovation decision: optional innovation decisions, collective innovation decisions, and authority innovation decisions; it can also influence the consequences of an innovation that are the changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation (e.g., desirable vs. undesirable, direct vs. indirect, and anticipated vs. unanticipated). This implies that change agents should understand the social system for planning the diffusion process effectively and efficiently.

Hall and Loucks (1978) developed the Concerns-Based Adoption Model (CBAM) based on the following assumptions about innovation adoption: (a) change is a process, not an event; (b) the individual is the primary target for change; (c) change is a highly personal experience; (d) individuals involved in change go through various stages; and (e) facilitators must know at what point their clients are in the change process. CBAM consists of seven stages: awareness, informational, personal, management, consequence, collaboration, and refocusing. These stages of concern about the innovation provide a key diagnostic tool for determining the content and delivery of individual development activities. Individuals with different kinds of concerns will be present in a group. For enhancing a diffusion process, individuals' concerns must be reduced. The most prevailing measure of stages of concern might be a 35-item stages of concern questionnaire (SoCQ) developed by Hall, George, and Rutherford (1977). Many researchers have often used it to measure the intensity of each stage of concern (Liu & Huang, 2005). Such use implies that the questionnaire is reliable and valid enough to provide both meaningful data and information for planning change strategies. Consequently, HRD professionals will be able to access guideline for change interventions by using CBAM.

Technological improvement tends to alternate between short episodes of intensive change activity and longer periods of routine use (Tyre & Orlikowski, 1993). Managing the timing of adoptions consciously and carefully can be a

critical benefit for an organization pursuing both change and efficiency. Thus, managers need to devise plans for (a) creating opportunities for adoption, (b) utilizing those opportunities, and (c) exploiting periods of regular use of technologies for generating new insights and ideas. These plans will be helpful in tailoring new technologies to fit their organizational and strategic context.

Diffusion of innovations should be conducted in a two-way direction because it is a collaborative and context-specific process based on a mutual understanding about an innovation. Thus, adopters of technology should actively participate in customizing technology to fit their unique situation by considering both positive and negative aspects of technology. In addition, generators of technology should try to transfer resources and capabilities needed in order to use, modify, and generate technology to its adopters so that diffusion will be successful.

Technology Transfer, Organizations, and Culture

The three main aspects of technology practice are cultural, organizational, and technical (Pacey, 1986). Both the concept of maintenance and these three aspects of technology should be considered when making a technology transfer successful. However, most people tend to consider only the technical aspects, such as knowledge, skills, techniques, machines, and resources, in the technology transfer process. This lack of insight could be one of the biggest obstacles to making the technology transfer successful. Without a thorough analysis of both organizational and cultural issues related to technology, successful technology transfer cannot be expected.

Technological advances tend to increase complexity and uncertainty, make end users dependent on specialized experts, and build new knowledge hurdles for potential adopters. In cases of the diffusion of complex production technologies, knowledge and technical know-how become important barriers to diffusion. Most organizations delay in-house adoption of complex technology until they obtain sufficient technical know-how to both implement and operate it successfully. Reinvention and learning-by-doing might be responses to the difficulty or incompleteness of technical knowledge transfer between donor and recipient organizations (Attewell, 1992). Technical know-how is relatively immobile, and it must be recreated by user organizations. As a result, the burden of developing technical know-how through organizational learning becomes a hurdle to adopting new technology. Given such hurdles, the relationships between donor and recipient organizations in a network go beyond selling and buying equipment. Service is an alternative to adopting or not adopting a technology. In such a case, consumers obtain the benefits of a new technology by having someone else provide it as a service, rather than by taking on the formidable task of organizing the technology in-house for themselves (Attewell, 1992). In such scenarios, knowledge barriers are lowered and the process of technology diffusion is accelerated. Organizations that have already experienced the benefits of a technology via a service provider constitute a pool of already-primed potential adopters that are likely to adopt technologies in-house once knowledge issues or other barriers are removed (Attewell, 1992). Consequently, a transition will occur from service to self-service. In other words, shifts from market services to in-house deployment result from a progressive lowering of know-how barriers.

Lowering knowledge and technical know-how barriers could be achieved by the efforts of both donors and recipients of technology. Donor organizations must innovate, not just in their design of products, but especially in the development of novel organizational mechanisms for reducing the knowledge or learning burden upon recipient organizations. Recipient organizations should try to create and accumulate technical know-how regarding complex, uncertain, and changing technologies. This implies that HRD professionals should capitalize on a learning organization strategy as a framework for the successful transfer of technology. A learning organization focuses on the values of continuous learning, knowledge creation and sharing, systematic thinking, a culture of learning, flexibility and experimentation, and a people-centered view (Watkins & Marsick, 1993). This strategy is regarded as one of the most effective organizational strategies to use for adopting changing technologies. If the learning organization expands the concept of learning from the individual level to the team and organization level, this can help organizations effectively and efficiently create and accumulate technical know-how. Such a strategy for learning will contribute to enhancing the implementation of technology transfer as well as organizational performance

by increasing learning and innovation. In addition, HRD professionals should try to create an environment that can induce the motives of both organizations and individuals to adopt new technologies for successful technology transfer. To do so, HRD professionals should strive to provide their potential users with opportunities to observe the benefits of new technologies.

Many post-World War II technical aid efforts by the United States and others failed because donor countries ignored and misunderstood both natural and cultural environments, assuming that all countries should follow the same pattern of industrialization (Pursell, 1993). The failure of these technical aid efforts led to appropriate technology movement; people realized that many useful technologies in donor countries might be detrimental in other countries and under other circumstances. Appropriate technology is primarily an innovation strategy aimed at achieving a good fit between technologies and the contexts in which they are intended to operate (Pursell, 1993). Values within the context play a pivotal role in determining the appropriate technology. In other words, appropriate technology aims at endogenous technological development within local communities and regions as a fresh approach to the problems of technology, society, and environment. Consequently, appropriate technology movement contributes to the importance of the contexts that involve cultural and natural environments in a technology transfer process.

People tend to maintain their own values and identities. This tendency led to the emergence of a variety of cultures. The beliefs, ideas, and customs that are shared and accepted by people in a society are based on cultural variables. Cultures often influence how technology is used in the technology transfer process. This fact is clearly supported by the case study for transfer of Western management concepts and practice from developed countries to Malawi. The aim of the case study was to relate findings to the education and training of managers in Malawi and consider their appropriateness (Jones, 1995). The finding recommended that Western management ideas must be critically examined in light of Malawian sociocultural realities (Jones, 1995). This implies that technologies must be tailored to fit the culture of end users in order for technology transfer to be successful.

Factors Affecting Technology Transfer

Technology transfer implies the movement of physical structure, knowledge, skills, organization, values, and capital from the site of generation to the receiving site (Mittelman & Pasha, 1997). The invisible aspects of technology, such as knowledge, skills, and organization, might be much more critical than the physical aspects for the successful transfer of technology. The case of the "Green Revolution" in India shows that technology is a form of knowledge created by humans, and knowledge transfer occurs as the outcome of a set of learning experiences (Parayil, 1992). This illustration implies that education and training play an important role in facilitating the movement of invisible aspects of technology. In other words, the capacity to assimilate, adapt, modify, and generate technology could be obtained through education and training.

The significance of education and training is also found in the cases of Japanese industrialization and Indonesian farm mechanization. In the early stage of Japanese industrialization, science and engineering universities and company schools contributed to facilitating the transfer of a marine steam turbine generator by providing capabilities for learning the new technology (Matsumoto, 1999). The capability of Japanese companies, acquired through education, made it possible to actively seek out new technology for the purpose of gaining competitive advantages, despite the economic risks.

On the contrary, Indonesian farmers failed to transfer agricultural machines for farm mechanization because of the lack of education, training, and other political and compatibility issues (Moon, 1998). Technology transfer should almost always involve modifications to suit new conditions. This implies that the unsuccessful transfer of agricultural machines in Indonesia resulted from the recipients' lack of absorptive capacity to assimilate and modify it rather than the donors' lack of sensitivity to local context for fitting the needs of end users. Technology is a passive resource whose effectiveness depends on humans. Consequently, one of the most critical components for effective technology transfer is a person's ability to learn new technology, which can be gained through extended education.

Although education is regarded as a critical and necessary factor for facilitating the transfer of technology, it is not sole factor for successful

technology transfer. Another important factor could be effective planning for facilitating that transfer of technology. The plan should include concrete ways that recipients and donors can collaborate during the technology transfer process. Collaboration might be based on willingness for technology transfer from both the recipient and the donor. Without a strong willingness for technology transfer on both sides, it is impossible to assimilate, adopt, and generate new technology.

In the international technology transfer context, most technology transfers are primarily guided by the profit motive. A donor country seems reluctant to transfer knowledge or capacity to a recipient country without the hope for profit. The article entitled "Technology Transfer: A Third World Perspective" provides a great implication about the issue. Third World countries embarked on a massive but passive importation of technology (Akubue, 2002). Many recipient countries in the Third World adopted these innovations without modification. Akubue (2002) further notes that arrangements like this could be the result of a strategy of the donor countries aimed at making Third World countries continuously rely on them for maintaining the new technology. Through this strategy of technology transfer, the donor country might also gain an additional advantage over purchasing raw material, such as oil or gaining political influence in the recipient country, in addition to profiting from technology maintenance.

A critical test of technology transfers is whether they stimulate further innovations within the recipient country. Third World countries should be able to achieve technology transfer that stimulates further innovations through an elaborate plan. The plan should include the best ways to benefit both a recipient country and a donor country equally. This plan might prompt willingness of both the recipient and donor sides, which would result in strengthening collaboration for facilitating technology transfer.

A New Model of Technology Transfer

A country's competitive advantages increasingly lie in its capabilities to generate further innovations and to use effectively new technology, which is generally a function of the capacity of its population to absorb new technologies and incorporate them into the production process (Kolfer & Meshkati, 1987). This implies that a successful transfer of technology has a large impact on the advancement of a nation and it significantly depends on the capacity of people to assimilate, adapt, modify, and generate new technology. Consequently, educational infrastructure to develop "human capital" is the basic component for a successful technology transfer. After accumulating a high quality of human capital, a recipient of technology should develop an elaborate plan to increase the willingness of both the recipient and the donor of technology transfer. This plan could facilitate the transfer of technology by strengthening the collaboration between the donor and the recipient. Lastly, the recipient should be able to generate new innovations based on the successful transfer of technology. This model can be shaped as shown in Figure 1.

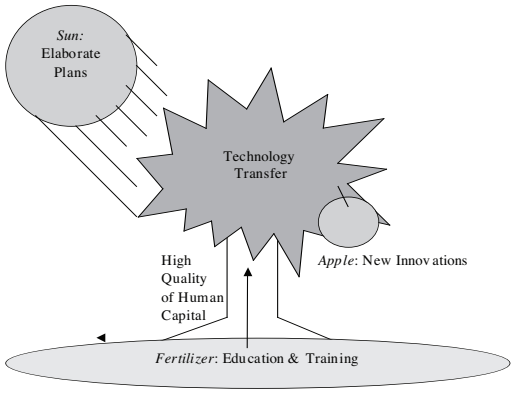

Figure 1. The role shifting model of technology transfer

This figure is titled "the role shifting model of technology transfer" because its ultimate goal is to generate new innovations. This model depicts how recipients of technology in 2009 can be tomorrow's donors of technology: It shows the conditions that enable fruit to ripen or in other words, new innovations. Thus, a high level of continuing education and training results in the role of fertilizing or helping an apple tree (technology transfer) grow well. In addition, elaborate plans for collaboration between recipients and donors help achieve successful technology transfer as either sun or rain is helpful for the growth of a tree. Consequently, farmers who are recipients of technology will be able to produce a plenty of fruit (new innovations) based on a high level of continuing education and training (fertilizer) and elaborate plans that play a role of sun and rain.

South Korea's successful transfer of technology for its national economic development might have followed the role-shifting model of

technology transfer. South Korea transformed itself from an agrarian society to one of the world's most highly industrialized nations. The South Korean economy has grown remarkably through strong government support and engaged people (i.e., high quality of human capital) since the early 1960s. Koreans have tried to accumulate a high quality of human capital through education because Korea has few natural resources. Koreans regarded the export of its industries as the only means to get above poverty the early 1960s. As a result, government and business leaders together fashioned a strategy of targeting export-oriented industries for development in the early 1960s. The strategy involved plans for the successful transfer of technology that generates new innovations. This strategy was implemented in a series of economic development plans. Textiles and light manufacturing were the first targeted industries, followed in the 1970s by such heavy industries as iron and steel and chemicals. Later, the focus shifted to the automotive and electronics industries.

In the early stage of industrialization, Korea made concrete plans that included multiple steps for the transfer of technology due to strong government support. In addition, Korea possessed enough highly educated citizens to assimilate, adapt, modify, and generate this new technology. These factors made technology transfer in Korea successful, and they ultimately helped to achieve its remarkable economic growth. As a result, Korea became a donor of technology in high-tech fields, such as electronic, information technology, and communication.

Summary and Recommendations

For effective technology transfer, a provider of technology must first change the adopters' perception and willingness for the acceptance of technology by understanding their cultural and social values before transferring the information on technology. During this process, informal communication and relationships are very important (Johnson et al., 1997). Formal communication should precede informal communication in order to build credibility or obtain trust from the adopters of technology. The solid formal communication would be able to make the informal communication more effective.

The transfer of technology should be conducted as two-way communication, not one-way communication, because it is a collaborative and context-specific process based on a mutual understanding about an innovation. Providers of technology must play a key role in facilitating the transfer process by helping the adopter reconstruct technology, based on the given situation. Transferring technology helps the adopters reinvent innovation that is suitable for their environment. Thus, providers of technology should try to transfer to its adopters all resources and capabilities needed to use, modify, and generate the technology. In addition, adopters of technology should actively participate in customizing technology to fit their unique situation by considering both the positive and negative aspects of technology.

HRD professionals in donor organizations should create strategies to recognize the complex and distinctive realities of the contexts where technologies are intended to operate for the effective transfer of technology. One of the strategies might involve development of cross-cultural training. HRD professionals in donor organizations should conduct an elaborate and thorough context analysis in order to make cross-cultural training for technology transfer effective and efficient. In the process of context analysis, HRD professionals should thoroughly investigate the compatibility of technology, dimensions of cultural differences between donor and recipient organizations or countries, economical and political issues, and physical constraints affecting the use of technology.

In contrast, HRD professionals in recipient organizations should develop a transformational learning program for successful technology transfer. Transformational change at the organization level might be the result of double-loop or transformational learning that requires learners to change their mental schema in a fundamental way (Argyris, 1982). In other words, any organizational change cannot be made without a transformational change process. Therefore, transformational learning is vitally important for the successful transfer of technology in the recipient organizations. This implies that HRD professionals (i.e., change agents) should develop a transformational learning program to make a technology transfer process effective and efficient.

The successful transfer of technology can be achieved by generating new innovations. Technology transfer should not be seen as an end in itself. It is a means to increase the rate of technological innovation and to stimulate new

innovation. Thus, today's recipients can be tomorrow's donors through a successful transfer of technology. To be a donor of technology, the recipients of technology should first possess the capacity to assimilate, adapt, and modify the imported technology through education and training. At the same time, the recipients should be more sensitive to technology cycles by continuously anticipating technology requirements as opposed to responding to them. This notion for recipients of technology to become anticipatory, not reactionary, is aligned with identifying emerging knowledge, skills, organizations, values, and trends. It can be a way to achieve the ultimate goal of technology transfer, which is actually developing new technology.

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