IDEAS
1. Rethinking the Issues of International Technology Transfer

by Ochieng Fred Walumbwa

Technology transfer has become a hot topic in business, industry, nongovernmental organizations, governments, and academia in the past several years (Baker, David, & Soucy, 1995; Johnson, Gatz, & Hicks, 1997). With an increase in the speed of technology transfer, especially from the West to the developing world, issues of technology transfer demand special attention. There is a need to develop a universally accepted view and definition of technology transfer by integrating the various models. Such an integrated model would include sociocultural, economic, and political factors pertinent to the adoption and diffusion process. This article draws upon the existing definitions, views, and models of technology transfer to provide a conceptual model of international technology transfer that encompasses sociocultural, economic, and political factors that bear upon the adoption and diffusion of technology.

Various definitions of technology transfer exist. Williams and Gibson (1990) defined technology transfer as the moving of ideas from a research laboratory to the marketplace. Thus, technology transfer is an exchange of technical information between the research and development workers who innovate and the end users (Rogers, 1995). The problem with these definitions is that they are too academic. They ignore the environment and tend to assume that once proper channels of communication are in place, transfer and diffusion should occur. While these definitions focus on technology as the core, they also neglect other important elements, such as sociocultural, economic, and political environments that impact technology transfer. An inclusive definition of technology transfer should include the transfer item; the developer of the technology; various channels to accomplish it, including communication; and the end users (Market, 1993).

Leonard-Barton (1990) classified technology transfer into two generic rhetorical situations: point-to-point and diffusion. Point-to-point implies that a source develops an innovation for a highly specified purpose to a known audience user. Diffusion suggests that a source develops an innovation for a more general audience user whose purpose may or may not be clearly known. Unfortunately, most of the technology transfers take this latter form of diffusion.

The Model

The conceptual model of technology transfer (see Figure 1) has three broad categories surrounding the core technology: (a)

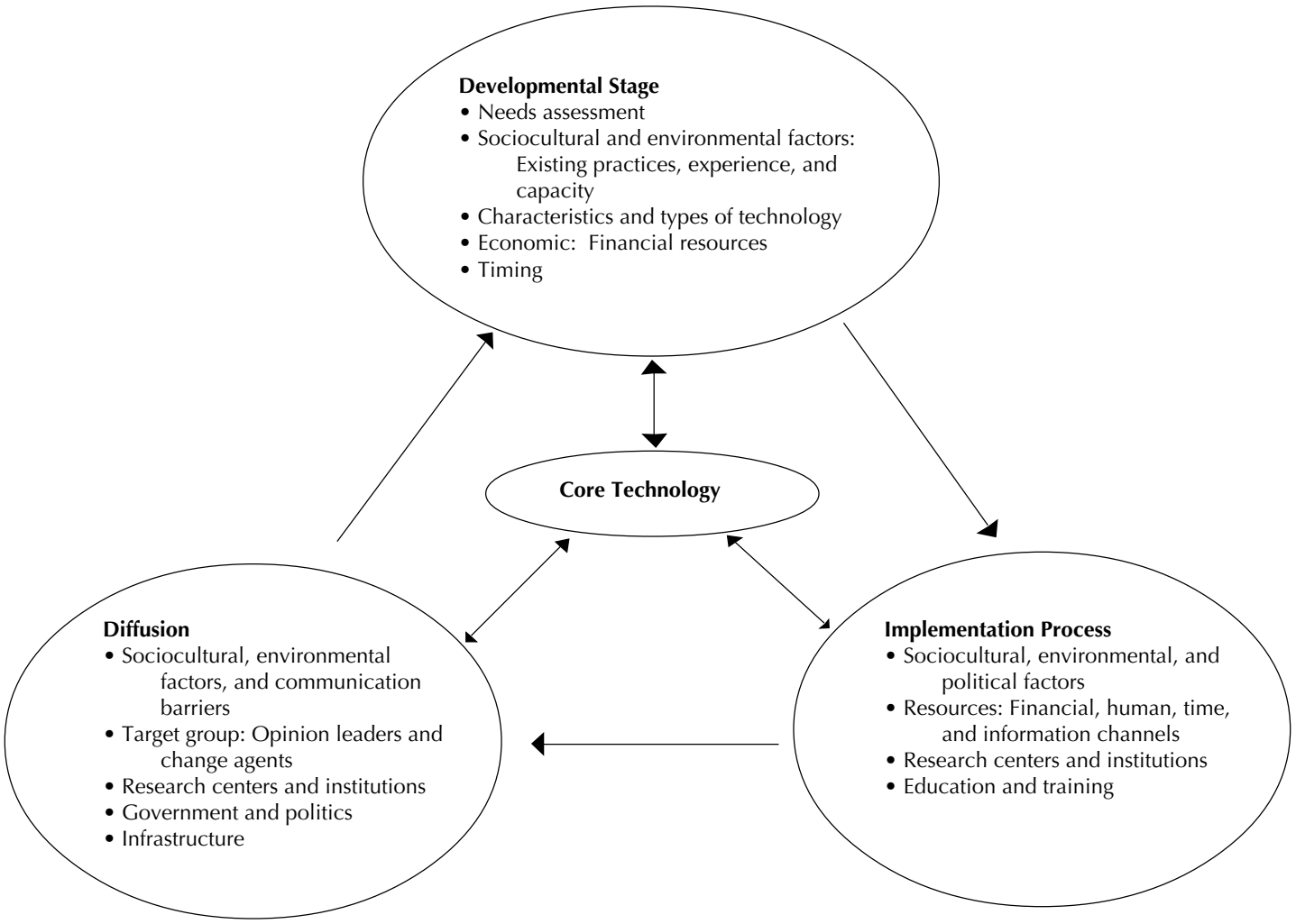

Figure 1. **Conceptual model of technology transfer.**

developmental stage, (b) implementation process, and (c) diffusion. Technology transfer in this model is a cyclical rather than a linear process whereby the developers of the new technology collaborate with other forces of transfer, including the end users. This arrangement is important because it gives the developer an opportunity to assess future strengths, weaknesses, opportunities, and threats that might enhance or inhibit successful transfer. This way, the developer is able to apply appropriate strategies for implementation and diffusion of the new technology.

Technology transfer starts with a new idea, or a modification of an existing one (Johnson et al., 1997). The double-sided arrows in the model infer that the variables in each of the three categories (developmental stage, implementation process, and diffusion) reciprocally affect the core technology being developed or modified. Some elements are found in more than one category of the model. This implies that these elements have multiple roles in the entire process of technology transfer. For example, an understanding of cultural, environmental, and political elements is important in the design stage to enable the developer of new or modified technology to find the "best fit." Technologies designed and developed with due consideration of the end users' needs and wants are likely to be adopted faster because many of the transfer barriers will have been addressed in the assessment. Culture, environment, and politics also play an important role not only in the transfer process, but also in diffusion (Rogers, 1995).

The elements in the developmental stage are concerned with the intended end users of the new technology being developed or modified. These elements are specifically important in the design stage because they enable the developer to comprehend the culture of the intended local users, their economic capability, and their levels of willingness to use the new technology. A careful assessment of these elements should be a prerequisite for further steps in the transfer process. The implementation process elements are vehicles that facilitate technology transfer (Jones, 1995; Parayil, 1992). Reynolds and Nadler (1993) argued that most international technology transfers fail at the implementation stage, perhaps because these elements are underutilized by the developers of new technology. According to the model, the development of human resources, such as capital and research institutions, are prerequisites for sustainable development of new technology. These institutions may be used as training centers for the end users to enhance their participation and ownership.

The diffusion process is the final stage in this model. At this stage individuals or groups of people decide whether or not to adopt and use the new technology. In most developing nations, given their traditional and cultural orientations, the role of the government and opinion leaders is paramount to successful diffusion of any new technology. Although infrastructure may not be under the control of the developer, it serves as a measure of the potentiality of the intended end users.

ELEMENTS OF TECHNOLOGY TRANSFER

Needs Assessment

Needs assessment is the first step in determining the needs and requirements of a specific country or society in which a new or modified technology is to be transferred. It is a systematic examination of conditions conducted for the purpose of identifying general strengths, weaknesses, and opportunities of the proposed technology in relation to the intended users. Needs assessment helps incorporate new technology into the prevailing physical and cultural environments of the receiving country (Kofler & Meshkati, 1987). Savage and Sterry (1990) suggested that the following questions are important when conducting needs assessment: What will be the social costs? What kind of personnel, materials, tools, and knowledge will be needed to build, install, and operate the proposed new technology? What risks are associated with the proposed technology? What risks will the new or modified technology present to other physical environments? Answers to these questions are likely to provide solutions to what have been characterized as timing, cultural issues, communication obstacles, and problems of infrastructure (Rogers, 1995).

Although needs assessment is important, it is often ineffective in the transfer of short-term, fast-changing technologies—either due to changes in consumers' tastes or the speed of advancement of a particular technology—such as computer software. Nonetheless, some sort of assessment in terms of consumer survey to determine product effectiveness is necessary. Obviously, needs assessment is a prerequisite for long-term technologies—technologies with lasting effects on the end users, for instance, educational, training, economic, and political policies.

Sociocultural and Environmental Factors

Sociocultural and environmental factors are embedded within the three categories of the model. Technology and culture impact one another; for instance, the introduction of new technology brings profound effects on a culture and people's beliefs, and some changes may even occur in the characteristics of community customs. Such changes are likely to have an influence on the transferability and/or diffusion of the technology. Therefore, it is imperative that we consider the role of sociocultural factors in the process of developing and transferring technology. In many instances, economics and political urgencies have been the driving principles of the development of the new technology—not the status of the end users. Consequently, disappointing results have ensued.

This model suggests that the practices and experiences of the intended users need to be considered in determining the appropriateness of new technology. Failure to consider cultural constraints, for instance, was reported to have contributed to the unsuccessful transfer of the American tractor to Russia (Dalrymple, 1964). Socialist authorities gave more weight to political factors than to sociocultural factors of the Russian people. Technologies constructed within an existing culture have the greatest chances of success because the developers can use local institutional frameworks to identify problems and opportunities.

Characteristics and Types of Technology

The transfer of technology is greatly influenced by the nature and type of technology being transferred (Rogers, 1995). Rogers (1995) identified five characteristics of innovation: relative advantage, compatibility, complexity, trialability, and observability (herein referred to as technology). Relative advantage refers to the degree to which the new technology is perceived to be much better compared to the existing technology. In the American cotton textile industry, the draper loom was easily transferred and diffused in the South in the 1960s because of perceived advantages such as labor savings (Feller, 1974). By contrast, the perceived disadvantage of its high initial cost hindered its adoption in the North.

Compatibility is the degree to which the innovation is consistent with the values, needs, and experience of the recipients. For example, the role of societal norms and values was a major factor in the transfer and diffusion of technology in the American textile industry during the 19th century (Jeremy, 1973). However, not all technology transfers need to be compatible or interactive with the local situations to be effectively adopted. For example, large innovations such as structural adjustment programs for developing nations require the bureaucratic procedures to get fully adopted. Complexity is the degree to which an innovation is perceived to be difficult. If technology is perceived to be complex and difficult by the end users, it may not be transferred easily. One example of this is the fast adoption of the "Sembradora" by the Mexicans despite

the numerous advantages of the large tractors brought in by the Americans (DeWalt, 1978). Trialability is the degree an innovation can be experimented on a regular basis before final adoption. This characteristic has been widely used in business organizations and in agriculture. Observability is based on the assumption that people are always motivated to learn new things. This concept explains the motive behind people's scrambling for new products or services whenever they are first introduced into the market.

Economic: Financial Resources

Technological transfers require high financial resources. In most cases they involve substantial amounts of capital that must be met by the recipient nations. Consequently, economic capabilities of the intended end users must be analyzed at the developmental stage. Such analysis provides an opportunity for the developer to design technology suitable for the local economy for sustainable development. Before a commitment is made about a new technology, the following questions should be asked (Savage & Sterry, 1990): What will the proposed new technology cost to build or operate? How does that compare to the cost of the alternatives?

A new technology may have relative advantage and compatibility with the existing situations, but if the cost of maintenance and operation exceeds what the intended nation can afford, it becomes a burden. This is typical of some of the heavy and sophisticated machinery that was transferred to developing countries, especially in the field of agriculture, that the recipients could not maintain. Financial capabilities of technology recipient nations need to be given significant consideration if the process of technology transfer is to ensure continuity.

Timing

Although the concept of timing has received little attention in the technology transfer literature, it plays a very important role in an innovation's ability to progress (Johnson et al., 1997; Rogers, 1995). As in any competitive environment, good timing is a valuable strategy for successful technology transfer. India's Green Revolution (Parayil, 1992) is a classic example of new technology coming at the right time. The country had been undergoing a devastating drought so that any attempt to provide a solution was readily accepted.

Education, Training, and Human Resources

Education and training are major factors in the successful facilitation and implementation of technology transfer. The periods preceding independence in Africa witnessed a massive investment in education and training by the Western world. This was intended to develop and to train African human capacity capable of handling Western technologies. Further, it hoped to prepare African nationals to fill positions left by colonial masters. Indeed, this turned out to be a good strategy. Africans were able to successfully replace their former masters. Education and training probably provide the best vehicle to successful technology transfer. Educated and skilled people are more apt to use new technology than uneducated people since educated individuals adopt new approaches and alternative perspectives more readily. Therefore, some kind of education and skills are required to sustain the transfer of technology.

Communication Channels: Research Centers and Institutions

Communication is a process in which people share ideas (Rogers, 1995). But that communication proceeds more readily between individuals with similar backgrounds in education, social status, beliefs, and language than between people of different backgrounds. Unfortunately, most transfers of technology involve people with different backgrounds, such as country, culture, discipline, or language. Therefore, learning to overcome communication barriers is a prerequisite for successful transfer of technology. The use of existing research centers and institutions may be a good strategy to facilitate the transfer of technology.

Target Group: Opinion Leaders and Change Agents

Change agents and opinion leaders are important elements in the transfer of technology. They are individuals who are knowledgeable in the social and political life of their respective societies. Many of them have been recognized by society for their past performance; hence, they are very influential. Research has indicated that people are more likely to listen and adopt ideas of those who are familiar to them than those they meet for the first time (Rogers, 1995). Therefore, it is important to establish some form of connection with the local leaders who understand the culture in which the new technology is to be introduced.

Government and Politics

Politics plays a central role in the transfer of technology because it directly influences culture. Before the demise of the Communists, for example, Africa was divided politically into Eastern and Western blocks. During this period, the transfer of Western technologies in military, agriculture, and education reached most developing countries through the support of the local governments. Another classical example may be found in the Structural Adjustment Programs initiated by the International Monetary Fund. Lack of government commitment has been cited as a major cause of program failure in almost all communities where there have been failures. Since successful technology transfers require a coordinated approach between the receiving governments and the developers, we need to recognize the role that the state plays in the dissemination of new ideas, whether it is a democratically elected government or otherwise.

On the other hand, politics can be a hindrance to the transfer and diffusion of technology. This is especially true when the transfer has to go through bureaucratic processes that are likely to impede the transfer. Sometimes this is very costly, especially where administrative structures in infant stages encourage corrupt practices.

Infrastructure

Infrastructure includes such facilities as transportation, banking, housing, schools and colleges, research institutions, and telecommunication systems. Infrastructure is one of the obstacles to the transfer of technology in developing countries. The transfer of most new technologies requires laboratories, workshops, and even housing. Banks are needed to handle financial transactions for the running of daily activities within and without the new technology location. Colleges and research institutions are crucial to sustain and develop core personnel who can ensure continuity of the process of technology transfer.

Closure

Technology transfer is critical in today's complex world. There is an urgent need to address the pressing issues of culture and environment in the process of developing and transferring technology. This conceptual model has attempted to address these issues specifically in relation to other vital elements of technology transfer such as communication, needs assessment, power and politics, infrastructure, and the characteristics of technology. Like most models developed in this area, this model is restricted to the author's own experience and background. Consequently, the model may require modification to fit different experiences and backgrounds although the elements would remain the same. More studies are needed that integrate factors such as culture, politics, and physical environment in modeling technology transfer.

Ochieng Fred Walumbwa is a doctoral student in the Department of Human Resource Education at the University of Illinois.

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2. Evolving Models of Technology Teacher Preparation

by William D. Paige

For years we have read articles, observed presentations at conferences, and heard reports of numerous research efforts concerning the shortage of teachers for technology education programs across the country (Householder, 1993; Volk, 1997; Weston, 1997; Young-Hawkins, 1996). There are many reasons for the shortage of technology education teachers, and the problems are complex. This article attempts to provide an overview of one facet of this issue by first outlining the traditional way in which teachers have been prepared and licensed and/or certified to teach in the public school systems in the United States. Second, several alternative methods of obtaining teaching licensure and/or certification are presented, followed by some personal thoughts about these alternatives and the future of our profession.

Historically, the most common way to prepare for a career in teaching in any field of study has been to complete a four-year bachelor's degree program in education. This traditional college- and university-based teacher preparation program is based on the belief that "becoming a teacher requires several years of preservice professional training and supervised practical experience prior to assuming full-time teaching responsibility" (Stoddart & Floden, 1995). According to Sullivan (1995), traditional teacher certification programs are usually characterized by a specified number of credit hours to be earned in (a) content area, (b) professional coursework, and (c) an internship. After the candidates successfully complete all requirements for the baccalaureate degree in education, the colleges or universities verify that they have met the minimum state licensing requirements. These state licenses and/or credential requirements signify to the public that people with either of these endorsements possess a level of professionalism and high standards and are at least minimally qualified to teach in our schools (Sullivan, 1995).

Householder (1993) explained that many of today's teachers of technology education were and are being prepared in programs based on the traditional historical model of teacher preparation. One might question the wisdom of this approach when considering that the traditional process of teacher preparation has received much negative attention in the past decade. Specifically, reports from the National Commission on Excellence in Education's (1983) publication of *A Nation at Risk,* the Carnegie Task Force on Teaching as a Profession (1986), and the Holmes Group (1986) among others, have all raised questions about the quality of our education system, including the process of teacher preparation. Concern has been voiced regarding the declining average ability of students and the trend of more academically able students choosing careers other than teaching (Schlechty & Vance, 1983). The recognition of the importance of quality teaching, the low college entrance test scores of those wanting to teach, and the reality of a future teacher shortage are among the factors that have led to numerous propositions demanding changes in higher education and proposals to reform the way teachers are prepared.

One of the proposals for reforming teacher education would require that teacher preparation programs be extended to five years. This proposal is based on the assump-