Effects of computer technology transfer on engineering education in third world countries

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Considering engineering education, with the rapidly evolving technologies, the time gap has increased considerably for a technology to be transferred and adapted in third world countries. A successful transfer of technology requires certain preexisting capabilities in the recipient country to be able to adapt that technology. "Innovation now seems to appear at a rate that increases geometrically, without respect to geographical limits or political systems. These innovations tend to transform cultural systems. Thus technology can be conceived as both a creative and a destructive process." (8)

This paper will focus on the implications that computer technology currently has on engineering education. Both positive and negative effects of this technology will be discussed along with the social changes that can result from this type of technology transfer.

Introduction

The economic health of nations is closely related to their capabilities in science and technology arenas. Scientific and technological activities on the international level are governed by a vast web of international and domestic laws (3), however, internet and computer technologies have opened new venues in the transfer of technology to Less Developed Countries (LDCs). The capability to transfer scientific or technological resources to these countries can indeed affect other issues that LDCs are facing today. The issues concerned here are engineering education which in turn affects a number of other capabilities such as manufacturing, commerce, military, and industrialization. Indirect effects of such changes could bring about unforeseen social and political changes in these LDCs.

Engineering education and benefits of e. learning

Engineering schools universally have a common objective. The objective is to turn out graduates with strong backgrounds in basic engineering and science, who can continue to learn on their own after they graduate. (6)

Globally universities are innovating new methods to train students to solve problems, learn, and relearn throughout their life. In this context, expectations are high and one of the methods pursued to deliver engineering education is through the use of internet educational applications. "New technologies provide many ways to enhance and expand educational activities. A wide range of educational material is now available in a variety of formats, including audio, video, simulations and animations, and is easily accessible through the net. Web-accessible databases allow teachers to share and reuse pedagogical material, for instance ARIADNE Knowledge Pool (Forte *et al*. 1997), Réseau Universitaire des Centres d'Autoformation, RUCA, http://www.univ-enligne.prd.fr/, simulation libraries such as http://www.eoe.org, remote laboratories such as http://iawww.epfl.ch/, and virtual laboratories such as http://www.esr.ruhr-uni-bochum. De/VCLab/ and tutorials such as http://www.engin.umich.edu/group/ctm/. Projects for pedagogical material capitalization and for open distance learning diffusion are strongly supported by the European Commission, which considers education as one of the most strategic applications of Internet development. Students are also active online, sharing course notes on student portals (see, for instance, http://www.alafac.com)." (7)

For successful use of web based instructional materials, Developing Countries need to undertake some initiatives in providing web services that are larger in scale, well managed and secure. Web information necessitates daily updating, and the best way to guarantee continuous updating is to provide direct data access to all the users, students, teachers and administrative staff. (7)

Michau also discusses the way to involve educators in the production of computer related material. The modification of pedagogic strategies is for the institution to bring educators rewards in terms of acknowledgement or financial support. From the educator's point of view, after an initial time-consuming effort, pioneers who use web-based support intensively for their teaching appreciate being able to:

- "Obtain high-quality and well-structured pedagogic material;
- Integrate online references that enrich and update their own material;
- Facilitate self-learning tasks that help students become actors in their education rather than simple consumers;
- Support student collaboration and extended work groups involving foreign students and experts from industry;
- Provide 'learning by doing tools' such as simulation, virtual laboratories and remote laboratories." (7)

At the international level with open distance learning, each university may broadcast its courses globally. A number of universities are now intensively developing online services through regional/national/international consortiums. "In Europe several kinds of ODL programs are being developed: for instance, the UOC, Universitat Oberta de Catalunya, to support scattered place learning; AUPELF-UREF, université virtuelle francophone, to develop e.learning in French; and ARIADNE, Alliance of Remote Instructional Authoring and Distribution Networks for Europe, to support capitalization and sharing of pedagogical resources. In the USA, Stanford, Georgia Tech, Illinois, Maryland, NYU, Colorado, etc. are among the higher education online players. The ITESM Virtual University provides e.learning in Spanish to most of the South American countries. Even online education entrepreneurs are emerging, like Motorola University or the University of Phoenix with 85000 students and course authors paid with stock-options. Models to describe education units like the ECTS, European Credit Transfer System, are defined to allow international curriculum combination. Quality standards for open distance learning for both production aspect and delivery aspects are key issues at this time." (7)

Teaching engineering sciences completely online seems to have some strong limitations, especially for laboratory work and for group projects. Michau believes that in engineering fields, it is probable that the development of online curriculum for higher education will mainly be in the delivery of courses toward underdeveloped countries that lack expert educators or will allow the world-wide delivery of courses by expert 'stars', famous professors from prestigious universities.

Transfer of technology
This is a complex issue, both between and within a national boundary. The complexity of the transfer of technology from Developed Countries (DCs) to LDCs is driven by multiple factors. Rangnar Nurkse's propositions of Circle of Poverty (Fig.1) was not valid for countries other than the post World War-II countries of Europe. The difference here was that the human resources that already existed in these countries allowed the influx of new capital from the U.S. to be absorbed with ease. The Marshall Plan assistance was employed effectively to jump-start their stalled national industries and economies.(3)

The problem with LDCs is multifaceted. Generally, there is a lack of adequately skilled workers, technicians, and entrepreneurs, complete lack of allocated capital, and government corruption and centralization. Innovative human resource development through engineering education presents a viable breakthrough for nations trapped in the vicious circle of underdevelopment and technological stagnation.

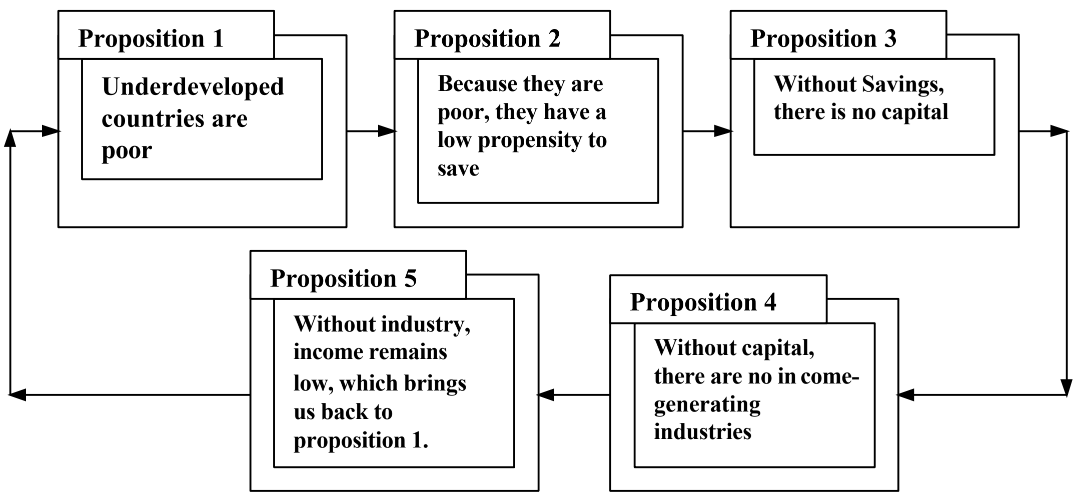

Figure 1 – Ragnar Nurkse Proposed circle of poverty

The concept of education as a means of technology transfer has been understood and utilized by many cultures in the past few hundred years. Developing Countries, interested in educating a modern labor force, see the United States as a source of education and technical training necessary for economic development.(9) This method of work force development is not without its weaknesses. For instance, lack of appropriate curricula for foreign students creates problems such as over-specialization in certain areas and acquisition of the type of skills unsuitable to transmit and utilize in their home countries. Even so, education abroad is still considered by far one of the most common practices LDCs use to develop indigenous scientists and technologists.

Today, industrialized nations import and outsource almost all the manufactured goods to a greater extent. Multinational corporations use every means possible to transfer newly developed technologies in fast and effective ways to the countries with huge untapped labor markets, and to the countries considered as the major industrial producers of goods. Availability of advanced electronics, computer and Internet technological resources have created technology transfer methods vital to today's economies.(3) The following comprise some of the most commonly used practices to transfer technology:

- Library and public domain materials available on the World Wide Web
- Multinational Corporation utilization of computers and Internet resources in work force training, and exchange/collaboration of projects across the globe
- Web-based courses and programs available through the institutions of higher education
- Educational materials developed as textbook companions and instructor support, accessible on the web.
- Multimedia educational materials available for sale, such as CDs, video tape, etc.

LDCs' engineering practices as well as engineering curricula have been affected as the result of the above-mentioned resources. Following is a list of such subject areas:

- Fundamentals of engineering; the subjects of statics, strength of materials, dynamics, thermodynamics, etc., have been enhanced and made easily accessible.
- Robotics - development of new generations of robotics, international robotics competitions
- Joint projects - made possible by the availability of internet and World Wide Web resources
- CAD/CAM/CAE subjects
- Meaningful projects and research - made possible by the low cost and availability of electronic components sensors and controls.

The degree of success that a technology is transferred largely depends on the capabilities of the recipient country. The level of capabilities one particular recipient country possesses in turn determines the rate of diffusion of technology in that country.(4)

Factors determining the rate of diffusion of technology

Some of these factors are: trade barriers, absorptive capability of the technology recipient, patents, and other minute factors. Among the factors mentioned above, the absorptive capability of a technology recipient has the most significant effect on the rate of diffusion of technology.

The absorptive capability of the recipient country strongly "colors the character of the international product life-cycle and the diffusion of technology". If the technology recipient has substantial scientific and technological capabilities, it can readily absorb the technology and will have little dependence on the technology donor. In this case, diffusion can occur rapidly, and the transfer of technology may be profound. This gives the recipient new capabilities that will enable it to become technologically self-sufficient. If on the other hand the recipient country has weak scientific and technological capabilities, the diffusion of technology might be rather slow and the transfer superficial.(3)

Frame explains International product life cycle as the relationship between sales of a product and the diffusion of technology from the innovative country to the recipient country. One way to look at the international product life cycle is to look at it like a conventional product life cycle in four stages of innovation: growth, maturity, and decline. In the first stage the innovative country "enjoys export strength, since it is in a monopoly position in respect to the product". In the second stage, foreign firms gain access to the technology through licensing arrangements, direct investment from the innovative country, their R&D efforts, or Joint Corporation utilizing electronics and computer technology. "With access to the technology they begin their own production of the good." In the third stage, low labor-costs enable the recipient country to compete effectively with the innovative country in the world's markets. In the fourth stage, the recipient country produces the product with such low costs that it begins to export the product into the innovative country and compete effectively with domestic manufacturers of the goods.(4)

As demand for the product increases in the world markets, countries with even greater comparative advantage in labor begin producing the good. At this stage, these countries can produce the products more economically than innovative countries or recipient countries. Consequently, these countries become major producers and exporters of the product and compete effectively with all the other original producers. At this time, all original producers become net importers of the good.(4) This is predominantly the way products are manufactured today.

Brave new era

The era of industrialization and colonization has long since passed. In fact some schools of thought argue that modern society is no longer living in the industrial age of the earlier twentieth century. The postindustrial society is already a reality, and the complex socio-technical networks mediated by advanced electronics have made obsolete the institutions of nationalistic governments, capitalistic corporations, as well as heavily populated cities.(8) Advanced electronics and computer technology has proven to be effective in the transfer of newly developed technologies among different entities in the developed countries as well as between all other countries.(2) This method of technology transfer is also true to some degree between DCs and LDCs.

Difficult factors to predict

Long-term effects on human life, environment, and natural resources are secondary effects of new technologies. Inexistence of resources to remedy the negative effects of rapid growth, pollution, overpopulated cites and the consequences resulting from rapid industrialization without proper planning is evident all over the world.(8) To prevent the negative environmental effects of a technology that is transferred, the transfer needs to be comprehensive and complete. This means if sciences and technologies that produce a family of products are transferred, the sciences and methods of environmental protection and hazardous material removal need to be transferred as well. Transfers of technologies designed for environmental protection or human safety are viewed unfavorable by the LDCs governments and corporations due to the price tag that these technologies carry.

Social, religious, and cultural consequences of transfer of technologies to other countries are highly unpredictable. Rapid industrialization and changes has in the past resulted in some cultures revolting against the influx of new technologies and abandon the benefits of westernization in general. A solution to the problem of social dislocation caused by the transfer of advanced technologies to developing and less developed countries has caused some with little faith in comprehensive planning and technology assessment to advance the concept of appropriate or intermediate technology as an alternative to rapid industrialization.(8)

Intermediate technology encompasses technologies used for practical answers to the urgent needs of the people in the developing countries. Food and agricultural technologies, power, urban housing development, education, healthcare and exploration of energy resources can be named as few of the intermediate technologies.(5)

Conclusion

Advanced electronics and computer technology has undoubtedly revolutionized the way engineering sciences and technologies are effectively transferred globally in the shortest amount of time possible. These resources benefit those countries with competitive advantages in labor resources and are producing a variety of goods for the world markets.

The engineering academic community currently has access to a wide range of material on the internet. This has led to an explosion of information, particularly with regard to current research and teaching methods. Engineering is suited to the use of educational technologies ranging from simulating dangerous environments, to replacing laboratory and factories difficult to maintain and impossible to walk through.(2)

The use of computers in engineering education allows practical experiences and help in data analysis. Although, work would often be impossible without computers, there are many advantageous in the utilization of computers in teaching and learning but, there are many difficulties in using the new technologies. A few of these disadvantages are lack of appropriate software and hardware, lack of time, technical support and technical expertise on behalf of the instructors, etc.(1)

One issue remains the same; a less developed country's technological diffusion rates remain the determinant factor in the successful utilization of scientific knowledge transferred to these countries. Although, in this era scientific knowledge can be transferred in a much shorter time, technological advances and innovations are happening at a faster and an exponentially shorter amount of time. Therefore, LDCs are lagging behind even further. These countries lack the fundamental expertise and knowledge required for the diffusion of the fragmented sciences and technologies transferred electronically.

More readily accessed scientific material, publications, and other sources of knowledge have enhanced technology transfer to the Less Developed Countries. Rapid transfer of scientific information coupled with the purchase of new technologies through goods available in the world markets, shows some positive effects on the quality of science and engineering education at the higher education institutions in these countries. But, unfortunately the lack of a cohesive link between the higher educational institutions and industry results in a premature and incomplete use of the knowledge gained. "Some so-called developing nations have never experienced the factory system and other institutions of industrialization. The leaders of such countries tend to feel that the acquisition of modern weapons and new technology will provide them with power and prestige".(8) Unless these countries start to pay drastic attention to science and engineering education and develop a technologically competent work-force, their technological gap with the rest of the world will grow even wider resulting them to be purely consumers of technological goods.

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