TECHNOLOGICAL DEVELOPMENT AND ITS IMPLICATIONS FOR EDUCATIONAL PLANNING

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The characteristics of technological development in industrialised countries is that the demands for goods and services have become more education-intensive. Such development has become internationalised. The internationalisation of technological production has a considerable impact on the training system in different countries. Developing countries are also rapidly industrialising themselves. However there is a fast change in the technological process. As a result failure to give due consideration to technological changes is one of the chief shortcomings of educational planning. The result of this planning deficiency is the mismatch between education and employment. It is necessary for the developing countries to keep themselves abreast of the state of technological progress around the world and choose the type of technology that will make maximum contribution to the longterm development of the country.

Introduction

Technology is the science of the application of knowledge to practical purposes. Technological development is therefore the progress that is made in this application. Related to the socio-economic context, technological development would mean progress in the application of knowledge to improve upon conditions in the economy and society.

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As countries move from being agricultural to industrial economies and then on to post-industrial information societies, their characteristics change in many ways, including the role demanded of education and the employment of the work force.

The development of science and technology has resulted in increased importance of research and education, increased complexity of organisations, greater importance of communication, more of the work force in information, a major role for the mass media, and to a greater degree of interdependence, while on the individual level, there will be longer life expectancy and more free time and a decrease in time spent on transport, a lower population growth and level of urbanisation.

With the advancement of biotechnology, food shortages can be eliminated and health facilities improved. It is believed that improvement of the environment will also be made possible by rational application of biotechniques. Progress in material science in the industrialised countries is not only leading to automation and restructuring of the employment pattern, work style and types of jobs through the use of "micro chips", but is also believed to bring about economies in consumption of energy, reduction of environmental hazards and change in the life style of people.

It has been observed that there has been growth of jobs in the service sector and a decline in manufacturing jobs in almost all industrialised countries except for Japan. The differences in the types of jobs in the two sectors and their different patterns of evolution have implication for education and training.

An interesting feature of technological development in the industrialised countries is that demand for goods and services has become more education-intensive in terms of production inputs, although there has been an increase in low level service workers such as waiters, sales workers and janitors. The exports of the industrialised countries tend to be more education-intensive than their imports. But due to the development of information technology, technology transfer enables an increasing shift of formerly education-intensive production of goods and services to the developing countries. New technologies are contributing to the internationalisation of the means of production and the implications of this for educational planning become very difficult to assess in a rapidly changing situation.

Changes in technology in the industrialised countries have had an impact on the relative productivity of different types of labour, since some applications of technology require better educated workers, where technology is embodied in forms of capital that complement education, or less educated workers where technology can be used as a substitute for education, eg, computers have reduced the educational requirements of analysts by carrying out the measurement, manipulation and analysis tasks previously done by human beings. In some cases, technological development has led to more worker participation in decision making by releasing workers from repetitive routine work (which is done by computers) for such tasks as deciding on product quality, production-

scheduling and assessing production needs – tasks which need numeracy, literacy, reasoning, communication and problem-solving skills, calling for ever higher levels of education among workers. Thus, it has been argued, as time passed economies will need higher levels of skills in certain areas, while forces like technological development leading to automation may help skill requirements in other areas. This leads one to believe that technological development is not likely to change the average level of skills required in the employment market of the industrialised countries in the near future. However, new technologies and new forms of work organisation will require new types of skills such as communication and reasoning. In the information society, an increasing number of workers are needed to create, process and distribute information. New occupations are created, and some old occupations will disappear or be transformed.

Factor costs of goods and services are also undergoing significant changes. It is estimated that the manufacturing costs of semiconductor chips are about 70 per cent knowledge (ie. research, development and testing) and only 12 per cent labour. In some pharmaceutical products, labour costs account for only 15 per cent and knowledge costs 50 per cent. Another study reveals that 15 per cent of overall productivity growth in American and Japanese industry comes from changes in the use of labour, 25 per cent from capital investment, but no less than 60 per cent from technological change.

Such developments will lead to rapid obsolescence of skills, requiring the retraining of workers from time to time. These trends have been noted in all industrialised countries. At independence, the developing countries had to expand their educational systems, since developmental efforts and departure of expatriates holding high-level decision-making positions created a heavy demand for education in quantitative terms.

As to development strategies, industrial development was generally favoured over agricultural, because planners and politicians thought that only dynamic industrial growth could create a modern state and lead to the economy to "take-off". It was also believed that this would provide the basis for sustained economic growth, increased consumption and improved overall economic condition of the people.

The production and consumption model imitating the industrialised countries was introduced in developing countries which had very different forms of income distribution, factor costs of production, size of internal markets, basic needs and scientific and technological capability. Structural heterogeneity of the economy was increased though the import of capital and knowledge intensive technologies in a few modern and powerful enterprises, and in many cases, development of local technological capability has been based on the needs of these large enterprises. Insufficient local demand for technological competence has tended to impede growth of national skills.

At the same time, the modern sector, expanding under the above circumstances very slowly and unevenly in these countries, has many of the same characteristics as that of industrialised countries. but with the addition of number of specific problems.

Technological Development and Internationalisation

The spread of international trade and investment is producing a very high degree of economic integration both among industrialised countries, and between them and the developing countries. It is against this background that a new international division of labour is emerging, in which the developed economies are not only reliant on Third World resources of energy and minerals but also on labour. This international division of labour, in addition to what has been said above, is also generating a limited amount of industrialisation in the developing countries.

Although technological knowledge of the highly trained manpower is essential for technology transfer, machinery and scientific equipment are important vehicles for the creation and dissemination of technology. The inter-nationalisation of their production is thus a mechanism for the dissemination of technology. However the spread or depth of penetration of new technology differs according to whether the machinery is intended for the manufacture of consumer, intermediate or capital goods.

Machinery that is specifically designed for a given activity, industry or group of activities is distinct from multipurpose machinery which can be used both to produce the first category and to reproduce itself. While all types of capital goods are vehicles for technological change, multipurpose machinery occupies a strategic position in the generation and dissemination of technology. Such machines govern the capacity to design and produce new machinery incorporating innovations for all the different sectors of the economy. The production of this type of capital good is henceforth dependent on the world market for machinery because it requires the import of some types of machinery and the export of others. The type of machinery in which a country tends to specialise within the framework of the international division of labour therefore determines the country's position in the production of technology at world level, ie, the production of knowledge directly related to the design of machinery is increasingly located in accordance with each country's specialisation in the different types of machinery. This is so, for example, for research and development (R and D) in mechanical engineering, chemicals, electronics and transport. On the other hand, atomic and space research is more directly associated with the arms sector and is conditioned rather by each country's position in the world military system. This situation evidently has consequences for the nature of the qualifications required and for the corresponding structure of training. The qualifications and skills required for the design of equipment and generation of knowledge are of a higher level than those required merely for the manufacturing process. The inter-nationalisation of technological production is therefore likely to have a considerable impact on the training systems of different countries.

Need for Technological Development in Developing Countries

The institutionalisation of wage-bargaining based on relatively full employment, and the increased competition of international trade are powerful stimuli to technological change in the developed economies. However, the creation and dissemination of techniques are mainly dependent on public research funding, and more generally on the organisation of technology transfers by the state, especially between the military sector and the civilian economy.

Studies show that whenever an innovation occurs, inter-country and intra-country disparities increase, at least in the short run. The benefits that accrue from innovation increase the wealth of those who are already rich. Thus the technological development that is taking place in developed countries tends to contribute to the widening of disparities in development. Unless local technological capabilities are developed on a world-wide basis, disparities will increase further.

The developing countries have an overriding need to expand their agricultural and industrial outputs and their basic services. These needs can only be met by rational technological changes achieved through the acquisition of the required knowledge through technology cooperation and the transfer of know-how from industrialised countries and its application for exploration, exploitation, management, distribution and conservation of the natural resources they possess. Consequently, developing countries have to be more conscious of the need to master technological change, at least in some strategic fields. It is being realized that technological dependence leads to economic dependence which, in its turn, affects political sovereingnty.

In order to be able to adapt a technology to local needs, it is necessary to master that technology: otherwise there will be serious losses of investments made in imported technologies just because that technology did not suit the local climate, conditions, and peculiarities of natural resources and culture of the people. Another reason for developing local technological capability is related to the serious unemployment problem facing developing countries in recent times. While imported machinery can be highly productive, it also reduces employment of human resources which in developing countries are normally available in abundance.

Finally, it is believed that the harmonisation of education and employment can be improved by linking the education system with the productive sector. This calls not only for flexibility of the educational system to meet of the productive sector but willingness of the productive sector to make the best use of the output of an increasingly complex and diverse educational system. Technological development provides a way to achieve this. However, the task of educational planners becomes more complex if a response is to be made to needs for technological development, especially in the context of internationalisation of technology.

Internationalisation of technology and the dilemma of educational planners in developing countries

The professional, technical and related workers, the managerial and administrative staff and the production related workers who run the economic machinery of a country are the product of the education and training system. Technological change, whether local or external in origin, however, entails new methods of production, calling for new types of skills. This necessarily alters the structure of education and training. Unfortunately, in many countries even when educational planning is regarded as a major instrument for economic development, it is rarely considered explicitly with reference to technological change. Conversely, technological development policies as formulated and applied seldom involve educational planning. However, evidence of an increasing gap between skills in demand and skills in supply suggests that an analysis of probable trends in technological change is becoming crucial to planning human-resources.

The failure to give due consideration to technological changes is probably one of the chief shortcomings of educational planning. One of the penalties of this planning deficiency is the mismatch between education and employment: shortages of certain types of skills and surplus of others From this point of view, traditional methods of manpower planning need to be revised. Certain methods in use assume that labour productivity is constant over a given time-span and consequently, any possibility of technological change is ruled out. Other methods explicitly envisage technological development, but equate it with a simple rise in labour productivity, represented by a coefficient of manpower needs. This ignores the impact of changes in techniques on the nature of jobs and skills. All these methods of manpower planning fail to integrate technological development and *a fortiori*, all the constraints that a technical change generated from outside entails for education in the developing countries. If educational objectives cannot be defined independently of technological change, and if the latter is mainly of external origin, as in the case of most developing countries, then educational planning has per force to be geared to the external forces.

In the developing countries, the constraints imposed by the internationalisation of technology are still more severe, inasmuch as these countries are weak in the production of machinery and of technical and scientific knowledge. Industrial development in most developing countries is confined to consumer goods and intermediate goods, and is based exclusively on technologies imported from the developed countries. This creates particular needs as regards skills. The repeated importation of increasingly specialised machinery and knowledge may entail the acquisition of more and more compartmentalised skills. Theses skills are increasingly restricted to the utilisation of imported machinery, and may not lead to their being used for local development, if deliberate efforts are not made in this direction. The internationalisation of technological production also tends to make the structure of skills more and more rigid, by imposing uniform technical standards on the world market.

Changes in the conditions of the worldwide production of techniques affects the goals of educational planning in the developing country. By unifying techniques on a world scale and by narrowing down the possibilities of choosing between them, it imposes a limited and rigid range of qualifications on educational planners. As a result of increasing specialisation in the production of machines, knowledge and skills, the application of techniques too is becoming increasingly complex. This is where the role of engineering to integrate compartmentalised areas of knowledge and to combine them with machines and skills becomes important. The development of engineering exports by multinationals may be perceived as a means of maintaining and reinforcing developing countries' technological dependence, since in part it extends to the diffusion of techniques the power of control already exercised by the large firms of industrialised countries over their production.

This can sometimes create obstacles to direct access by the developing countries to the world technology market, thereby making more difficult the definition of the aims of educational planning. In some extreme cases, control by external decision-making centres over the selection and implementation of imported techniques can effectively prevent planners themselves from formulating the training needs entailed by the imported technology.

In these circumstances, any educational planning becomes highly complex, since it is no longer possible to define training objectives. In extreme cases, it is left to the foreign firms themselves to train the managers, technicians and skilled workers (regardless of level of skill) called upon to operate the plants these firms have built. This happens with "turn-key" contracts, in which the national operator buys a factory complete with its full operating labour force. It also happens with international training contracts.

From the above discussion, it is clear that if educational planning is to be oriented towards making countries capable of deciding their own destiny, development of local technological capability should become an explicit objective. This calls for articulation of the desiderata of technological development. First among them is the capacity to remain abreast of the state of technological progress around the world. The second is the capability to choose the type of technology, which will make the optimum contribution to the longterm development of the country. The choice of techniques needs not only technological capability but also negotiation skills to decide on the terms of import. Even if import is of the "turn-key" type, the proper management techniques must be available for developing the skills needed. The third is the capability of assembling the different components of a machine. This has generally two stages: semi-knocked down (SKD) assembly where not all components are disintegrated and thus needing less sophisticated skills, and complete knocked down (CKD) assembly where all the parts are disintegrated. The third capability in order of sequence is to depackage the technology which would help national firms to get thoroughly acquainted with the different parts so as to adapt some of them to local need. At this stage the details of the theory of material properties and

manufacturing knowledge are needed. This leads to the fourth capability of designing products suitable for the country's own working pattern and needs. The last step which will follow design, is the self production of the equipment or machinery. Moving from one capability to another brings changes in educational needs and increasing sophistication. But at one particular point of time, all these capabilities may be needed simultaneously for different components of the same machine or the different products of the same firm.

However, it should be remembered that control over the organisation of production and technologies depends not only on the technical capabilities of the workforce, but also, and to a large extent, on the forms and levels of organisation adopted, and on how production is managed. In that case, control over the machinery of production also demands capacities pertaining to the organisation and management of companies and production facilities. In many countries, this organisational and managerial capability is sadly lacking, which thereby worsens the problems relating to control over technology alone. The implications of this for educational planning are obvious.

It should also be understood that the process whereby the above skills are selected and adapted to local conditions calls for a system to produce new knowledge, however partial. This leads us to the identification of research skills essential for local control over the process of technological change. If a country plans to substitute the imported knowledge needed in the production process by local knowledge, research skills are central to the overall process of selection, acquisition, control, adaptations and replacement of imported technologies by national technologies and imported products by new products. Development of human resources to perform this task of research is, therefore, a major responsibility of the education system. The broader goals of education—social, cultural and non-economic—have to be kept in mind in educational planning. Education also has a role to play in informing the population of the harmful effects of technological progress, for example health hazards and dehumanising effects and can assist the population in safeguarding themselves.

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