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OBJECTS OF SCIENCE EDUCATION IN UNDERDEVELOPED COUNTRIES

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The transformation of all the advanced or the rapidly advancing countries has been brought about by the acceptance, slowly at first, and now in an increasing measure, of a scientific and rational view of life and nature. This view has also permeated in a large measure the administrative bodies of the more advanced countries, tempering the outlook of individual executives, and increasing their ability to make responsible decisions, especially within the lower levels of the hierarchy of authority. This is the foundation of the modern age.

The purpose of this paper is to draw attention to the special needs of science education in underdeveloped countries which are characterised by an extremely low level of living, and widespread under-employment. In these countries, the only way to improve the level of living is to increase the per capitā production of goods and supply of services by an increasing use of machinery driven by steam or electricity as a substitute for human or animal labour. This will have to be brought about through industrialisation, in its broadest sense, of manufactures, agriculture, transport and communications, distribution, and similar areas of the economy. Only with the help of a rapidly increasing number of semi-skilled and skilled workers, technicians, engineers and technologists, physicians and scientists would this be possible. A strong base of science education is indispensable for this purpose and this point is widely appreciated.

Industrialisation, together with an expansion of both imports and exports, with an increasingly larger content of semi-manufactured or manufactured articles included among the latter, would be possible only through the most effective utilisation of domestic resources and for this to be done it would be necessary to develop and expand technological and applied research. This point is also appreciated when it is realised that even most advanced countries like the U.S.A. or the United Kingdom have to devote a third or more of their non-military research to improve the quality of products already in use to hold their position in a competitive world market.

To sustain an adequate base of technological and applied research it is essential to establish and foster a tradition of scientific research which would offer full scope for free communication and an exchange of views and criticisms among research scientists. This can be achieved only through the promotion of pure or pioneering research , because it is the research scientists who must function as the eyes and ears of the nation in the field of science They can foster the growth of the scientific tradition within the country and can maintain contact with the progress of science abroad. It is not possible for every country to take up research in all subjects. It is, however, necessary to encourage and provide facilities

for pioneering or fundamental research on a small scale either within the country itself or in regional or international research centres. Fortunately, pioneering research can be and has usually been done on a small scale and at low expense; every country, however small, can therefore offer facilities for this type of research. An important aim then of science education must be to supply an increasing number of qualified students for technical, technological and scientific institutions at all levels and for centres of both applied and fundamental research. This is essentially the utilitarian aspect of science education.

There is also a deeper need which is the heart of the problem of "modernisation" of the underdeveloped countries. The emergence of science during the last four hundred years, at first slowly and then at a rapidly increasing pace, is a turning point in the history of civilization. Before the emergence of science, there were only two broad domains of human decisions. In one domain there was individual freedom of choice of such items as food, clothes and recreations or of individual creative activities in art, literature, music, and the like within, of course, the limits permitted by society or of supplies and facilities available to the individuals concerned. The other domain of all organised human activities was and must always be regulated by the "principle of authority" in which sanction would depend on the status or level of the authority. This is true in all primitive or present day communities all over the world; in organised churches and religions; in military, police or administrative systems; in public and private enterprises; and in law. The decision of a law court may be upheld or reversed by a higher court of appeal, but the second decision also would be subject to confirmation or reversal by a higher court and so on. This process may be continued. The decision of the highest court to which a case has been or can be referred must be accepted; but there is no guarantee that such a verdict would not have been reversed if an appeal to a higher court had been made or were possible. This principle of authority must be accepted for the very existence of society itself.

The same principle of authority must, however, be completely rejected in the field of science. Cause and effect have been the subject of enquiry from time immemorial but only in respect of events in isolation. That natural phenomenon is amenable to rational and unified explanation is the great break-through of the human intellect. It occurred only with the emergence of science and is the characteristic mark of the modern age. Modern science consists of a patient accummulation of facts and observations and a critical study of their inter-relations based on the uniformity of nature which can be discovered by the human mind. Science thus introduced for the first time the concept or principle of objective validity which has its foundation in nature itself and cannot be changed or upset by any human authority however high. The findings of the most eminent scientists are subject to critical check and corroboration or refutation by their youngest scientific colleagues. A single new observation may call for a more comprehensive theory. The older accumulated knowledge would still remain valid, and later discoveries must be integrated with the earlier knowledge.

In the underdeveloped countries the most urgent need is to establish and develop the outlook of science, and the experimental attitude of mind so that knowledge of natural and social forces may be acquired and such knowledge may be used to invent new techniques for initiating material and social changes. This is the only way in which decisions can be made in an increasingly rational manner and in accordance with the principle of scientific or objective validity. This is the only way to replace superstition and out-dated custom

or dogma, and to bring about a change of society to make conditions suitable for rapid economic and national development by removing all barriers to the effective utilisation of all productive forces and all available resources for the benefit of all the people of the country.

The advancement of science and the growth of the scientific and rational outlook is an essential condition for the modernisation of the less advanced countries. It is necessary for each country, however backward or small, to have as quickly as possible sufficient men with a scientific outlook who would be able increasingly to influence the thinking of the nation and of persons who have the responsibility for making policy decisions at the national level. How to attract a sufficient number of persons into the field of science is thus a crucial problem in national and world development. This can be achieved only through an increasing appreciation of science and scientists by the general public.

The most fundamental aim of science education must therefore be to build up a community of scientific workers and to promote the social appreciation of science among the general public. It is necessary then to lay the foundations, with as wide a base as possible, for a country-wide system of school education oriented to science and at the same time to promote advanced studies of science and technology, and research at the highest level.

It would be a fatal mistake to establish an expensive system of science education on the model of the advanced countries which would be beyond the means of the nation as a whole. It is necessary to evolve, through experimentation and research, a system which would be available in time for all the people on a country-wide basis, but which remains within the means of the nation. School science must fit into the economic life of the general masses of the people and have its roots in the villages in underdeveloped countries. At higher levels, facilities must be provided for the training of technicians and technologists, and also for the training of candidates of outstanding ability for admission to higher scientific and technological institutions.

The approach must be to use teaching aids which would be easily available or could be made available at a low cost all over the country and, since most of the pupils will be living in villages, it would be advisable to use agriculture and rural industries as a general base for the teaching of science. The programme should consist largely of nature studies, observations, measurements and experiments which can be done with the help of simple articles and specimens, which are available locally or which can be constructed in the villages, using local materials. At the secondary school level, it would be necessary to introduce scientific instruments and equipment but these should be of the simplest types, preferably such as can be manufactured within the country out of domestic resources.

At all levels, the main object of science education should be to stimulate the spirit of enquiry and the desire to make observations and measurements or carry out experiments to find out something which is not known. It is essential to refrain from asking the students simply to acquire knowledge of facts or to perform set exercises in the form of practical work. In underdeveloped countries where the scientific tradition has not yet been established, such an approach would tend to make the students look upon science as something like magic or make them accept the facts on the basis of the authority of the teachers. If this happened the real purpose of the teaching of science would be frustrated.

Stimulation of curiosity about the external world and its inhabitants, and promotion of constructive and disciplined criticisms through scientific education does not alienate the growth of the humanities and of individual appreciation of the arts. For just as the scientific outlook tempers the rigidity of the authoritarian domain, so it also fosters a heightened awareness and appreciation within the domain of individual choice.

There is no conflict, in principle, between the three domains; first, of individual choice guided by social, cultural and spiritual values; second, of decisions in organised affairs determined by the authority of an appropriate status; and third, the advancement of science through free exchange of views among scientific workers of equal status. Increasing expansion and integration of all three domains of human decisions is an essential condition for the progress of civilization.

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