UNIVERSITY OF JAFFNA

Sir Ponnampalam Ramanathan
MEMORIAL LECTURE

Science And Technology Education As Harbinger To Development

by

Prof. V. NAVARATNARAJAH

1994

Science And Technology Education As Harbinger To Development

INTRODUCTION

The Sir Ponnampalam Ramanathan Memorial Lecture along with the Lady Ramanathan Memorial Lecture has become an annual event in our University. It has become a tradition to hold these lectures immediately following the General Convocation. The Ramanathan Memorial Lecture is funded by an Endowment instituted by the Board of Directors of Parameswara College, in 1980.

The memory of Sir Ponnampalam Ramanathan is very near and dear to us. The very premises and the buildings which form the nucleus of our University are closely associated with him. We are indeed thankful to those who instituted this endowment for giving us the opportunity to cherish Sir Ponnampalam Ramanathan's memory in a fitting manner.

This year, the Ramanathan Memorial Lecture is being delivered by Prof. V. Navaratnarajah who is the Professor of Civil Engineering in our University.

The subject Prof. Navaratnarajah has chosen for his lecture, namely, Science and Technology Education as Harbinger to Development, is an apt one, for I believe that the future of this region depends to a great extent on working out a sound Science and Technology Education Programme and its quick implementation. Prof. Navaratnarajah with his long teaching and research experience in the field of Engineering can be relied upon to come out with some valuable ideas and suggestions in his lecture.

University of Jaffna,
Thirunelvely.
1994-09-12.

Prof. K. Kunaratnam
Vice - Chancellor

SCIENCE AND TECHNOLOGY EDUCATION AS HARBINGER TO DEVELOPMENT

"At the early age of twenty eight, he was selected by His Excellency Sir James Longden to represent the Tamils in the Legislative Council. Then and from that day to the ripe old age of seventy nine years, whether as a masterful lawyer at the Bar, the silver – tongued orator on the platform or as the undisputed leader of the Council Board, he bestrode the public life of the country like a Colossus."

Ladies and Gentlemen, these were the words of Dr. C. W. W. Kannangara, a former Legislative Councilor and Minister of Education about the statesman whose memorial lecture I have been given the honour of presenting to you today in this campus which has been the beneficiary of one of the standing monuments he built for the furtherance of education. I hope I can do justice to the task I have undertaken.

Sir Ponnambalam Ramanathan was an educational reformer who gave this country's education his whole - hearted attention besides founding two institutions, namely Ramanathan College and Parameshwara College which became leading educational institutions and monuments to his memory. Along with his brother Arunachalam he conceived the idea of a University of Ceylon and laboured for its establishment. He was a passionate believer in education for all and in his address in the Legislative Council on 19 November 1879 on the growth of education, said (Vythilingam, 1971, p. 156).

"I do not think it is necessary to dilate on the obligation of the Government to educate the people. I think it will be conceded but I do not wish to press on you Sir, the fact that capital invested in education is reproductive."

Although Ramanathan is known for his deep involvement in Hindu religion and Tamil culture, he knew of the need to inculcate scientific ideas in his people. Besides his readings in law and religion, he read extensively articles on scientific subjects and their relation to philosophic thoughts. These articles are found even today in his collections which are in the archives of the University of Jaffna library (Ramanathan). His interest in science is to be expected as he was brought under the tutelage of his maternal uncle Sir Muthucumaraswamy who himself was a reformer and gave his country's education a new strength and impetus since he felt that this country should keep pace with the rest of the world in receiving scientific and technological education, and as a result of whose persistent efforts, the Science Laboratory was opened at the Royal College and the Ceylon Technical College established. Ramanathan had a vision for his people, a vision in which they were not left behind from the development of the rest of the world. Besides the field of education, he fought hard for development in various other spheres such as in the extension of the Jaffna Railway Line for quick transport of people and goods, the Post Office Savings Bank, development of irrigation in Ceylon and the opening of the ports in the north at Kayts, Kankesanthurai and Point Pedro for the transport of goods.

The subjects which claimed a good deal of his attention were the development of irrigation for agriculture by the restoration of numerous ancient tanks and water - ways which were in a state of disrepair, the reclamation of many millions of acres of fertile and productive land which had become jungle due to long periods of neglect and the settlement of landless peasants on this reclaimed land. H. A. P. Sandrasegara, K. C. said of him "During his life - time, Ramanathan said that the salvation of this country depended on its agricultural development. That was a thing he firmly believed in. He was a great legislator, councilor and educationist, but nobody would have thought that he could come forward to launch the Kilinochi Scheme.

He himself launched the Scheme and got 500 acres under the Iranamadu Scheme and cultivated it" (Vythilingam, 1977, p. 200).

Ladies and Gentlemen, perhaps you would agree with me that on recalling the memory of this great son of the soil, it is fitting that I speak on a subject that would do justice to his contributions in the fields of education and development. Being a person educated in the scientific and technological culture, I shall now present my thougts on how science and technological education can contribute to our future development.

Development through growth of Science and Technology

The concept of development appeals differently to different sections of people. Philosophers like Dower (1988) consider development as a process of social change that can be influenced by human action and as one that should take place with cognizance of one's culture. Economists like Bauer (1981) and Culbertson (1971) think of development as economic growth with equity. However, in the more general normative sense, which most of us can accept, development signifies economic growth, industrialisation or modernisation which leads to prosperity and advancement of the quality of life of the population. We believe that progress in science and technology would help us in such a development.

Develoment has been progressing from the time of early civilization. We are reminded that the earliest agricultural development based on the cultivation of primitive forms of rice and millet occurred in South - East Asia, somewhere about 10,000 B. C. (Roberts, 1987, p. 49). A study of the history of technology reveals that technology, albeit of a low level, had been helping early civilization. Jericho was a place where before 6000 B. C. farmers clustered around great water tanks which suggests provision for irrigation. Around 5000 B. C, all over the Near East, farming villages provided the agricultural surpluses on which civilization was raised. Around 6000 B. C. brick building was going on at Catal Huyuk in Turkey (Roberts, 1987, p.57) and similar spurts of technology in building with brick had been flourishing in the Indus and Mohenjodaro civilizations around 2000 B. C. (Jain, 1979). The most ancient water raising machine used in irrigation in the Islamic world as early as 2500 B C is the shaduf, a counter - weighted lever from which a bucket in suspended into a well or stream - a device which is still being used in the Middle - East and is similar to our own well - sweep. Other traditional water raising machines introdced between the third and first centuries B. C. in the Islamic world include the screw or water - snail. whose invention is attributed to the great mathematician Archimedes (Hill. 1991).

Technology is older than science. Any history of science would recognize that its roots are deep in the primitive technologies of human experience. Because of the wide - spread misconception that technology is applied science, there is a tendency to think that people in developing countries have no indigenous technology, technologies which are sometimes very old. Technology is sometimes viewed as something that can only be imported from the more developed societies. This concept of technology is held even by science teachers. In a survey of ninety - four science teachers in Western Australia reported by Rennie (1987), the vast majority stated or implied that there was no technology befor scientific discoveries were made.

Since we are aware that older technologies such as agriculture existed before the entry of science, it is important to know the contribution of modern science to development. Before the scientific revolution, progress was based on experience alone, which is an accumulative process over a period of time. Modern science, initially developed based on the Greek deductive philosophy, and the Italian Renaissance based on experimentation provided a scientific methodology. Planned experimentation allows for quicker and more reliable deductions. Thus modern science has the advantage in its application to all technologies over the more intuitive use of experience in pre-scientific societies. It is important to understand clearly the distinction between science and technology. The Oxford English Dictionary defines technology as 'the scientific study of the practical or industrial arts', but also as 'the study of applied sciences'. We could consider agriculture as the second oldest practical art and hence by this definition second oldest technology in the world - only food collecting and fishing are older! However, at a recent UNESCO International Symposium on the Teaching of Technology within the Context of General Education (UNESCO, 1985), the delegates agreed on the following definition of Technology:

> "Technology is the know-how and the creative process that may utilise tools, resources and systems to solve problems, to enhance control over the natural and man-made environment in an endeavour to improve the human condition".

The term technology is also often misunderstood with the term technical. It is important to clarify that technology is a complex system of inter-related factors with a large technical component which refers primarily to tools, machines, structures and other devices. Hence, besides the technical, there are other factors which contribute to technological systems namely economic, scientific, sociological and psychological. Technology may be summed up as having the structure of a problem-solving and goal-seeking system.

Greeks introduced scientific thoughts through their methods of abstraction and generalisation which sometimes led to wrong conclusions such as that the earth was the centre of the universe. The Polish astronomer Copernicus by his observations proved this to be wrong and proposed that the sun and not the earth was the centre of the universe. This revolution in scientific observation initiated by Copernicus was carried through by Galileo Galilei who was a great experimenter and triumphantly completed by

Newton by his enunciation of the three simple laws of motion and his fundamental generalisation, the law of universal gravitation. From this time, it was clear that science must ultimately guide the operations of the technicians and that a scientific technology would shape the future of civilization.

The gradual penetration of scientific method and discovery into the economic activities of production led to the substitution of analysis and instrumentation for the craftman's impalpable skill. However, even long after the close of the seventeenth century, industrial progress depended overwhelmingly on craft invention rather than on fruits of systematic scientific research. Although great achievements were being made in pure science, the basic elements of technology in the sixteenth and seventeenth centuries were not greatly dissimilar from that of earlier times,

A revolutionary change took place with the Industrial Revolution and the advent of steam power as an energy source. Even today, the level of development in a country is assessed by the amount of energy consumed by its people. The steam engine was seen as not only powering locomotives and other machines including water pumps used in mines, but also as an innovation that met the material demands of the consuming class. Steam was only to be dethroned as a power source by the invention of electricity by Michael Faraday and the advancement of the scientific knowledge of producing electricity. Electricity has become increasingly used in the motivation of machines and the subsequent electro - mechanical developments have eased the life of human beings, both in everyday life and the industries where they have improved the productivity and thereby the quality of life. Besides its increasing use in the industry, developments in electricity have spawned the age of electronics which in turn has contributed to improved communications. Today we are in the midst of a world of microprocessors, computers and digitised electronics which has led to a revolution in information technology. Equally important has been the impact of fossil fuels on development of energy and its utilisation in motor vehicles, power generation and irrigation in agriculture. However, while electricity produces energy as a clean technology, the burning of fossil fuels has created various environmental problems such as global warming and acid rain whose effects can include desertification. Another environmental problem that has surfaced with development has been that of ozone depletion caused by the use of chloroflurocarbons in cooling cycles in refrigeration and air conditioners, not excepting its use in the common aerosols.

Another significant contribution to development has been the advances in chemical technology and chemical engineering. The distillation of petroleum products from crude oil has spawned various petrochemical industries which have contributed to the development of chemical fertilisers and pesticides used nowadays extensively in agriculture; and polymers which have found their way into our homes and workplaces. The indiscriminate use of agrochemicals, however, has led to the deterioration in the soil chemistry and groundwater resources. A later occurrence has been the development of biotechnology which has found its way into all aspects of health and food related industries. One of the most exciting fields has been genetic engineering which has been used to develop new species of plant and animals which are of high yield. New high-yield varieties of seeds which are resistant to pests and insects have been developed, but these have been reported to need higher inputs of fertilisers and irrigated water than the normal varieties. In respect of the pesticides, it has been reported that less than one percent of these including herbicides actually reach target pests. Consequently more than 99 percent of pesticides applied may contaminate land, water, air, humans and other animals and wildlife habitat. Moreover, herbicides account for approximately 31 percent of the estimated oncogenic risk of pesticide residue in fresh foods and approximately 12 percent of the pesticide residue risk in processed food (Goldberg et al., 1990).

Science and Technology Relevant to our Development

The preceding discussion has highlighted the role of science and technology in the global developmental process. While accepting that there are benefits to be obtained from the use of science and technology, one must also take heed of the growing attack by a segment of the society on the heavy hand of technology. The natural - food movement is a popular reaction to the agricultural industry which uses chemical fertilisers and pesticides. There is a call for biofertilisers and biocides in agriculture. The recent " Our Earth " conference on environment held in 1992 in Rio de Janeiro, Brazil called for a sustainable development - a development that satisfies present needs without risking the needs of future generations and thereby ensuring humanity's long term future.

While considering for our use the technologies used elsewhere, it is prudent to inquire into the relevance of these technologies in our context and the necessity, if any, to adapt or modify them before using them. For example, a University of Philippines research programme called MASIPAG collected more than 200 older varieties of paddy and the scientists worked with the farmers to screen the samples for their ability to resist disease and yield well without expensive chemical inputs. The research showed that traditional varieties without chemical fertilisers and pesticides yielded 3.98 tonnes per hectare while the new high - yield varieties which required more irrigation and heavy dose of fertiliser yielded 3.87 tonnes per hectare (Cherfas, 1992). One must not lose sight of the fact that the local farmer has over a period of time learnt to grow crops that are resistant to pests by growing other plants near his crops to keep away the pests!

One of the main problems in our region is the limited water resources available for our agriculture and hence we need to use technologies that use limited irrigation to crops. Parthasarathy (1990) has reported how " life - saving irrigation " in the form of a single dose of water can increase land productivity by sizeable amounts. The recent advance with the greatest impact on furrow irrigation is surge irrigation (Anon., 1989). This technology which constitutes the intermittent application of water to alternating blocks of furrows reduces the infiltration rate on most soils so that water advances down the field more quickly and less water is required to wet the furrows along their entire length. The presence of an excessive amount of salts in irrigation or soil water has been a major problem in some of our areas. Agricultural engineers have developed carefully calculated drainage systems that, when properly managed, will keep the salts out of the root zone (Yensen, 1988). Similar approaches have to be made in the field of energy production. More attention is now given to the generation of energy from solar sources, wind - mills, biogas, producer-gas and wave - energy. Our southern neighbour India has recently announced the setting up of five wave - energy generating stations along the southern coast of Tamil Nadu to bring more electrical power to her people.

The examples that have been cited indicate the type of technologies that would be appropriate and useful for our needs. The chosen technology must also meet our basic goals of satisfactory food, shelter, health and environment, and be mindful of our present level of technological competence. If our technological competence is not sufficient for the purpose, our priority should be to improve the competence of our manpower resources through appropriate education in science and technology. In the event of having to burrow or transfer technology from outside sources, our manpower should be sufficiently trained to be able to benefit from such a transfer. Hence, it is imperative that a good foundation in science and technology in our education is a priority for our future progress and development.

Science and Technology Education

The Committee on the Teaching of Science (CTS) of the International Council of Scientific Unions (ICSU) stated in a paper presented at the United Nations Conference on Science and Technology for Development in 1979 the importance of science and technology education as follows (CTS, 1979, p. 10):

> "It is our opinion that the healthy growth of science and technology in any country depends initially on the availability of technically and scientifically trained manpower and that it is the responsibility of the indigenous educational system to provide such manpower. Furthermore, we would maintain that the successful exploitation and assimilation of scientific and technological develoment can only proceed with the support of an interested and informed public. The responsibility for fostering this interest and ensuring that the public is properly informed rests clearly with the educational system of the country concerned. Any policy that fails to recognize the importance of these two factors can, at best, produce only short term improvements; at worst, the country concerned could experience serious failures in technological development."

An important element in this statement is the emphasis on the need for the public to be informed of science and technology developments. Hence, it is necessary for our citizenry to be exposed to the ideas of science and technology at an early age with a view of promoting the appropriate technology that would take them towards the goal of sustainable development. At the present moment, the educational curriculum provides for compartmentalised teaching of science and technology and the impact of teaching of science is only felt at a later stage, namely the post - secondary or tertiary levels. The students also receive instruction with performance at examinations as their prime objective, and not with the view of a greater understanding of the subjects. The application of the scientific knowledge and how the different subjects taught affect the development process or contribute to it are aspects which are neglected in the teaching of these subjects.

The problems we face in the lack of the correct type of training being imparted to our children are partly a result of the continued adaptation of the British system of education. We should not forget that the British have designed their education to suit their needs commensurate with their level of development and it is for us to design our system to suit our needs. The present system is very good at producing youth with academic A - levels and university degrees but lacking in producing manpower with technical skills and vocational qualifications. It is not surprising that this system is now under attack even in Britain as its industry faces stiff competition from the industries of the European countries, notably Germany and Japan. German and Japanese firms with factories in Britain have expressed general dissatisfaction about the competence of the local workforce compared to that of the workers in their own countries. The Japanese felt that the situation at their Nissan's automobile plant near Sutherland in Scotland was so bad that it led to the virtual rewriting of the syllabuses at the local colleges (Anon., 1992). Germany and Holland have adopted in their academic training a substantial amount of training in vocational skills. The glory of the German education system is the so – called ' dual system '. It combines on – the – job training in a local factory and theoretical education in school. The system reinforces a culture in which technical education is cherished. The Danes delight in explaining that they have the edge on the Germans as Danish technical education puts more emphasis on theory than on practical knowledge. Presently, France and Britain are making heroic efforts to bring their educational regimes up to German and Danish standards and provide a broader curriculum in their schools which bring the academic and vocational divisions together. The lesson for us is that we should develop our own system of training in science and technology giving priority to the needs of our country and not repeat the mistakes of other countries.

Curriculum in Science and Technology

One has to be decisive about the type of development that is sought when designing a curriculum towards development, and the inputs of science and technology in such a curriculum. The devlopment that is suitable for us has been identified earlier as a sustainable type using technology appropriate to our needs and the efficient use of our natural resources. Appropriate technology is one that promotes economically small - scale production, local ownership and control, socially promotes social flexibility or adaptability, promotes self - reliance and community co - operation and ecologically protects existing habitat, restores viability of ecosystems, recycles organic nutrients conserves renewable resources, promotes use of renewable energy sources and promotes use of re - cycled materials.

The above amplification of appropriate technology gives us a good basis on which our priorities for the subjects to be included in our curriculum may be decided, namely those required in achieving our targets in the basic needs of food, shelter, health and environment. Agriculture related studies including dry - land agriculture, irrigation and utilisation of water resources and efficient land use would have a priority. Besides suitable inputs about fisheries and marine studies, attention should be given to an integrated study between agriculture. animal husbandry and dairy farming, aquaculture, use of land and water resources and developing renewable energy sources. Technologies and methods adopted in other countries should be introduced; the educational approach should encourage the borrowing of suitable technology from other cultures and suitably adapting them to local needs. Different approaches adopted in other countries could be brought into the classrooms as case studies. A good example of such an approach is the manner in which agricultural industries are located in the environs of the farms in Japan; this approach obviates the disruption in the location of agricultural workers who may otherwise have moved to the factory locations if they were away from the farms, thus creating a sociological problem.

Amplifying further in the field of agriculture, technology inputs could be made on the use of genetic engineering in the production of high - yielding cereals suitable to our lands i. e. producing varieties that can cope with reduced irrigation water or those that can be cultivated on dry or arid land or on saline soils (Yensen, 1988). Information on the development of biofertilisers and biocides and their use, on maximising the use of water in irrigation such as in furrow irrigation (Anon., 1989), or methods of reducing the evaporation of irrigated water (Parthasarathy, 1990) should be included. Inputs on high level technologies such as remote sensing and its use in land - use studies including the monitoring of forest clearance, in assessing the condition of crops affected by moisture, disease, insects and weather are also relevant (Bhatt, 1992). Methods of co-operation in the sharing of technology with developed countries could be brought to the attention of the students through examples of such co - operation such as that provided by the German Aerospace Research and Testing Institute in satellite remote sensing for meterology and mapping land for settlement purposes in India and Indonesia (Schmidt - Kuntzel, 1985). The success by Indonesia in using German technology for building de - salination plants using photo - voltaic mini-power stations or using wood - fuelled generators for irrigating rice fields in Picon village can be brought to the attention of the students. These examples show the type of input that can be made in the teaching of science and technology in our schools, thereby making them aware of the usefulness of these aspects in preparing them to face the world when they leave school.

The curriculum should also move away from the academic and vocational or technological divide that exists in the present educational system and adopt a unified one followed by all students up to upper secondary levels. This has been recognised in many countries which are in difficulties in their development due to lack of sufficient trained manpower in the technical and vocational fields. China has called for a reform in the upper secondary education from a predominance of general education to an equal mix of general education and vocational / technical education. The need for reform arose out of the large - scale industrialisation programme launched in the late 1970's and the serious shortage still prevailing in the early 1980's (Tsang, 1991). Similar steps are being taken in the United Kingdom to introduce more technology in the national curriculum at the Advanced Level as a stepping stone to technology in higher education. The Engineering Council (EC) has stated that " there should be a clear progression in content with the subject acting as a stepping stone to higher education and employment " (EC, 1992). The IPPR document " A British Baccalaureat " proposes a common curriculum i.e. instead of having separate academic and vocational courses, the curriculum would consist of a range of theoretical and applied modules within a single unified system (Finegold et al., 1990). Such a unified curriculum, it is argued, does not separate the preparation of young people for employment from the wider role of preparing them to become better citizens in a democratic society (Young, 1993).

After making a case for integrating science and technology with the general curriculum, the next step is to decide the level at which this integration is to be effected. Children are noted for asking questions like why and wherefrom as soon as they start talking and science is really about asking questions about the world around us. Hence, it is vitally important that this enthusiasm of the child is taken advantage of and the child exposed to the scientific ways of looking at things, even doing simple experiments at pre - school or primary school levels. It is however important that the notion that science and technology are different from the rest of life should at no time be presented to the child and should be treated like any other activity such as singing, painting or reading stories.

The new science curriculum that is being implemented in Japan in 1992 for elementary schools, in 1993 for lower secondary schools and in 1994 for upper secondary schools in their 6-3-3-4 system of school education where the first nine years - six years of elementary education and three years of lower secondary education are compulsory, is worth a close look. For the elementary schools, the subject of social studies and science have been replaced with a new subject called life environmental studies as an integrated subjects combining the two. Many selective science subjects are offered at upper secondary school. In addition to subjects which stress the systems of science as much as before, subjects which emphasize the relationship between science and human life as well as the applications of science, and subjects which aim to help students understand nature comprehensively (integrated science) have been created. Observation and experimentation are to be emphasized more than ever before in all science subjects from the elementary school up to the upper secondary school (Umeno, 1992).

Attempts have been made in the last few years in developing countries to relate the primary school science curriculum more to the developmental issues of local communities, in health and agriculture in particular. Concepts relating to life cycles are taught with examples drawn from the local environment such as the Anopheles mosquito because of its relevance to malaria. Combustion is being taught in relation to firewood burning, local cooking stoves and fuel economy rather than the burning of fuels in engines. Teaching of science and technology in primary schools should be related to science rich activities in the community. For example, it is useful in teaching about water pumps, to relate the children to the different kinds of pumps used locally, how they work, what commonly goes wrong with them and perhaps also how to fix them. A new innovation has been the recent development of comics as a medium for learning and teaching in the field of science and technology at elementary school level. Publishers in Japan regularly produce such comics to explain the range of issues from health to travel (Murray, 1992).

Science education at secondary school level seems to be designed primarily to prepare students for university entrance as it has to provide the foundation for more specialised scientific studies in universities. Its links with technology and with the every day world are tenuous and ill-defined. On the other hand, technology education deals with the technology that pervades all our lives and which determines the quality of life. For example, it is not sufficient to know all about plants in conventional studies in botany unless the student is able to correlate the knowledge to its use in agriculture. Hence, the curriculum would be more realistic if agricultural science is integrated with conventional botany syllabus. Probably the most established agricultural science curriculum with a wider focus on developmental science and society issues is the Agriculture as Environmental Science curriculum in Israel, which is co-ordinated with the biology and the physical science curriculum of Junior High School (Israel, 1978). It came to be respected as more relevant to social and developmental issues than conventional science courses and led to the full integration of agriculture and biology in the upper-high school Life and Agricultural Science curriculum which is interwoven with aspects of economics (Israel, 1980). There is also a need to inculcate in our community, ideas of consumerism and quality control in respect of goods produced. The existence of standards and the need to test the goods produced according to these standards must be brought to the attention of the community. This is probably best done in the secondary school curriculum when dealing with subjects of production, nutrition and health.

At the University level, the old departmental divisions of physics, botany, chemistry, zoology etc. have resisted the introduction of courses that suggest applied science or Technology until they found their garduates experiencing difficulties in employment in the development sector. Some of the universities introduced new courses in communication studies, informatics, computing, electronics, environmental science etc. in order to overcome these problems but had limited success. Another solution that has been attempted is to retain the system of offering courses through the old departmental divisions but group the courses provided in different ways such as a course unit system or a package system in which the contents of the package can be changed from year to year. It is apparent that in all these endeavours, the science teachers in universities are unable to break away from the straight - jacket of the departmental divisions. This is bound to continue in our universities as long as the bulk of our graduates in science are being produced for the teaching and administrative services and are not trained for their employment in the developmental and industrial sectors. A small number are presently employed as professionals in Medicine, Engineering, Dentistry, Veterinary or Agriculture or in the Scientific Administrative Service such as in the Government Analyst Department or the Standards Institution or in one of the research institutes such as the Tea Research Institute, Rubber Research Institute or the Coconut and Palmyrah Research Institute.

We need to develop courses at the university that would help the country in the developmental needs. In Biosciences, we need to introduce courses in Food Production and Nutrition (cereals, milk, meat) and Genetic and Cell Biology which are equally related and useful in Agriculture and Veterinary Science. Courses in Biochemistry are useful not only in Medicine, but to the ever widening field of Biotechnology. Manufacturing in biotechnology would be impossible without the support of courses in Process and Control Enigneering and Chemical Engineering. In terms of food processing and preservation for consumption courses in

Microbiology and Bacteriology are indispensable. Courses in Ecology and Environmental Engineering are important if our development is to be a sustainable one.

Manufacturing needs courses in production engineering and control engineering. These should be supplemented by courses in materials science, polymer chemistry and metallurgy. Computers are being used in all endeavours. Hence, besides courses in Computer Science and Engineering, inputs at least at an awareness level should be introduced in Robotics and Computer - Aided Design and Manufacturing in production of foods. One may question the necessity to introduce such varied courses in our tertiary curriculum. While it may not be necessary to offer complete courses, it is important to have sufficient inputs in the present courses in the above aspects, perhaps as optional unit courses. Such a step would help our graduates to be fitted easily into various employment slots with minimum additional on - the - job training.

Conclusions

In summary, there is a need to reorganise our system of science education in schools and integrate it with the general education with relevant inputs of technology so that our students and hence the community would be able to appreciate the importance of science and technology to improve our material needs and quality of life, while participating fully in the developmental process. Our university courses in science and technology should be more innovative and designed to cater to the development needs of our region. The university should train our graduates to make them capable of conducting relevant and meaningful research that would help in our advancement. This is consistent with the accepted fact that the development of a country depends on the availability of scientifically and technologically trained manpower. It is the responsibility of the indigenous educational system to provide such manpower. There is always an inertia against change and this is partly due to an examination system that determines what is being taught. Thus there is a vicious circle that needs to be broken if progess is to be made to reach our goals. I will conclude by quoting, Taylor (1984) from his paper on Life - long Science Education and Its Role in Development which reads as follows :

> " The attitude of the public at large are determined by first introductions at a very early age; these attitudes can be disturbed by prejudice and traditions in the home. Teaching in universities influences teachers at school; and good practical teaching and research in a university depends on a supply of trained technicians. This, in turn, depends on good technical teaching, but even more so on the development of positive attitudes towards careers in science and technology. So we see how convoluted the processes are. The only hope of breaking the circle is simultaneous attack at all levels. "

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