Science, Education and Society:
perspectives from India and South East Asia

Kenneth King (editor)

International Development Research Centre
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The Education Programme and the Science and Technology Programme have for more than ten years existed as two of several distinct programmes within the Social Sciences Division of the International Development Research Centre. Since August 1982, these two programmes have sought to make one of their many activities quite explicitly interdisciplinary, and as a consequence in three regions of the developing world have been exploring possible research connections amongst the inter-related fields of science, technology, education, employment, manpower and training. The resulting programme has been named TEED - Technology, Education and Employment for Development, and Kenneth King, previously the associate director of the Education Programme in Ottawa, was asked to act as advisor and co-ordinator of its development.

There would be little purpose in an agency pursuing an interdisciplinary initiative that did not reflect a parallel movement and interest amongst researchers in developing countries. This volume makes abundantly clear that there already exist in many developing countries some new and exciting lines of inquiry that cut across science education and science policy, computer policies and computers in schools, school science and people's science, government action and popular movements. Perhaps nowhere are these clearer than in India; hence the strong Indian focus of this volume. But in other countries in South and South East Asia it is becoming evident that the kind of interdisciplinary research that marks these papers is also present.

The bulk of these papers were presented at the IDRC seminar on Education, Science Policy, Research and Action which took place in New Delhi in January 1984, and which thus became very appropriately the first seminar to be held in the newly opened South Asia Regional Office of the IDRC. It is deeply regretted by IDRC and the organisers of the seminar that Dr. Nida Sapianchai of the Thai Institute for the Promotion of Science and Technology was unable to attend this workshop because of a sudden illness from which she died two months later. Her presence is much missed.

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Introduction

When IDRC suggested that I might assist them to explore some of the interdisciplinary connections between Education, Science and Technology Policy, and Employment I had already become aware that there was scope for looking over the boundary walls of education on the one hand and of science and technology policy on the other. The task was made easier by the fact that neither of these two has had much history as a 'discipline' in its own right. The 'sciences' of education and of science and technology are both of very recent birth and their lineages are somewhat cloudy, to say the least. With the benefits of hindsight, however, the hybrid nature of these two disciplines has been an advantage. Thus, popular science movements have attracted atomic scientists along with adult educators, whilst national science policy has drawn the attention of economists, sociologists and psychologists, as well as historians.

Put a different way, this suggests that there is an explicit bias in this volume: that in treating of science education, it is listening to the science educator who is not just concerned with improving the science curriculum of formal schools, but who is looking outside the school walls to the impact of science on society. In looking at science and technology policy, it is looking beyond that national statement of policy to the many different local valuations of science and of technology, some of which long predate the recent view that every self-respecting nation must have an S & T policy. In viewing the almost unstoppable march of new information technologies into society and into the classroom, it is less concerned with the technical questions than the social and political issues that attend this latest apparent threat to the South's capacity to catch up with the industrialised North. The volume, therefore, is fundamentally concerned with the two faces of science: science as power and science as hubris, or science above values and science without values. It is therefore entirely appropriate to have represented in it the evidence from countries that illustrate the transforming power of science, in Singapore and South Korea, as well as countries like India where modern science exists in enclaves, and where the scientific temper is still as much an aspiration today as when Nehru first borrowed the term.

The thrust of much of the volume is to question mainstream science, whether in school or in society, and to raise issues about how to reinforce the interest in alternatives. Although in many ways the criticism of 'big science' has been intellectually successful, it is equally obvious that big science remains in the saddle, providing the inspiration for the international agricultural research centres, for the emphasis on defence science, for the peculiar priorities of medical science, for the fascination with biotechnology, genetic engineering, and for the many information technologies that developing countries have little option but to adopt. Over against the
power of establishment science, the forces of dissent are currently weak, but there is gradually developing an agenda of issues and approaches that is the beginning of an alternative paradigm. It is still very weak in the formal school and university system; it is much stronger in the nonformal movements of town and countryside, but it still has few institutions committed to its diffusion. One reason therefore why Farzam Arbab from Colombia in Latin America was present in this meeting, and in this volume, was because of his institutionalisation of an alternative approach to scientific knowledge and to its formal acquisition.

It is too early to surmise the outcome of the tension between massive investment in modern science and the growth of a popular awareness about alternatives. This is likely to become as much an issue in the South as in the North, even though in neither sphere today does the gathering criticism of development theory adequately deal with the place of science and technology. But as it grows, it seems inevitable that this awareness will touch science in schools, and technology on the farm, and that it will draw into the same conceptual framework an understanding of the relationships between science, new technology, employment and unemployment.

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A REVIEW PAPER

Kenneth King
Yet a basic question remains unanswered: can these (learning) processes indeed generate enough forces to counteract the forces of social disintegration? Strangely enough, from among the individuals and institutions who have in one way or another helped FUNDAEC, its own originators are the most critical and the least optimistic in this respect. Although they have never wished to attack any specific social or political group, they cannot deny that the hundreds of millions of rural inhabitants of the world are oppressed by a world system consisting of the two strong contending powers and their many subsidiaries and variations. By simple inertia or by design, the fruits of the hard labour of these millions are sucked away and are channelled to finance the thousands of mechanisms, including reform and revolution, used for the maintenance of the world system, and its favourite occupation, the production of weapons of destruction. Can the inhabitants of Norte del Cauca truly hope for a higher level of material well-being under these conditions? A simple transfer of a sum of money from one bank to another or a political alliance at a moment of convenience generate irresistible forces that determine the prices of their products, how much land they can possess, what technology they can use, and which propaganda they should be subjected to. How can their fragile economy withstand these huge forces of dis-integration? The people of Norte del Cauca have certainly proved with FUNDAEC that, once offered viable alternatives, they are willing to participate in the processes of change. But change at the village level is only half of the challenge of development. The so-called developed world, including the modern sector of the Third World countries, also has to change; in the final analysis, a prosperous village in Norte del Cauca can only exist as an organic part of a totally new world order.

Introduction

The above quotation from a description of science-based change in a backward region of Colombia points up several of the themes addressed at a meeting of science educators, sociologists of
science, engineers, science activists, science analysts and science policy makers. There is, firstly, the concern with continuity and change at the micro-level, whether in individual schools, villages, farms or forests in developing countries. Second, the learning processes associated with these changes seem broadly related to the impact of the particular traditions of science and technology, be these popular science, or appropriate technology, indigenous science or new technology. But thirdly, and most crucially, there is a question mark hanging over the larger science and technology system at the global and national level. In contradictory positions it is argued that science must be brought to all, in school and outside, and particularly in the Third World to make man modern and productive and more competitive with the industrialised North. Equally, it is argued, as in the above quotation, that whatever the innovativeness or dedication of the individual scientist in the village or science classroom, the wider texts of science and technology in the nation state and international economy do not reveal characteristics of objectivity, progressiveness and universalism, but rather betray a set of codes intimately connected with large scale capital, intensive systems of knowledge production, whether for agricultural, health, military or industrial application.

Although the broad outlines of the debates about the role of science and technology in development have been available for some time, this particular meeting was concerned to examine in greater detail several illustrations of the general debate. First, it seemed useful to examine the interaction between the policy debate about science and technology on the one hand and the rich variety of research and action on promoting science and technology through formal and nonformal learning on the other. Second, the disputes about the beneficial and/or baneful impact of science and technology might profitably be set against the extraordinary diversity of science-based intervention by committed individuals and groups in the rural areas of the Third World. Thirdly, both these activities, of science-in-education, and popular-science-for-villages, could exemplify or challenge interpretations of developing country science as broadly dependent on the initiatives, research, and priorities of the more developed, industrialised world. In the elaboration of these very local descriptions of science in action, it might be possible to judge whether there were indications that science was playing a liberatory role in rural community development, and in the encouragement of individual achievement, or whether, by contrast, the very process of applying science to the varied situations of rural and urban poverty was throwing up the need for new paradigms, alternative ways of thinking about the interrelations of science, education, technology and development.

Since a central concern is to bring into the same set of discussions the developments in science in education and the developments in science in society, it is important to make an initial comment about these two science milieux. Following Bernstein, it should be admitted that science in school, or college
is a fundamentally different activity and has a very different discourse from science in the world outside. The subject frames of school science are different, the pacing is determined by criteria completely different from the practice of science in the professions, government and industry. And yet in many curriculum statements, there is the suggestion that school science will offer insight into and practice in the scientific method.

There is a need accordingly to sort out the many different aspirations attached to the scientific enterprise in school, to distinguish these from the motives underlying the interventions of committed scientists in rural areas, and both from the practice of science and technology in the particular country. In any such analysis it becomes clear that a great deal is expected from formal and nonformal science. In school it is variously expected to communicate modern outlooks on the world, to help less developed countries to 'catch up', to allow pupils to participate in some aspects of scientific method, to give disadvantaged pupils a weapon with which they can offset social or caste bias. Similarly, in many different interventions in the countryside, the role of popular or people's science is multi-faceted, ranging from consciousness-raising, to promotion of appropriate technologies, to the dissemination of a scientific temper among the masses. Indeed a listing of the objectives culled from Indian intervention initiatives demonstrate the extraordinary mix of expectations associated with people's science:

i to popularise scientific knowledge among the masses;

ii to develop a scientific outlook among the masses;

iii to challenge the forces of supernaturalism, obscurantism and superstition;

iv to equip the poor with knowledge and skills to analyse and articulate their demands and rights in an effective manner;

v to re-assess modern 'Western' science and technology which has grown mainly within the historical and economic context of colonialism;

vi to re-evaluate non-Western or indigenous traditions in search of an alternative science and technology for our society;

vii to develop appropriate technology and popularise it;

viii to motivate professional scientists to work on problems that are relevant for the lives of the poor people;

ix to involve science researchers, teachers, and students in mobilising the masses for structural change in society;
to build pressure on state structures to ensure that decisions are taken in a rational manner;

to popularise self-reliance and the use of local resources in matters such as health, education, housing and industry;

to develop a critical awareness regarding the methods used in the present system of education, and to develop an alternative method of education, especially science education, that would be relevant to children's own lives.²

When, in addition to these science-based strategies for rural areas, and the set of assumptions about the potential of school science, there is included the science and technology policies of the state more generally, it becomes clear that science is being drafted by many different interest groups to represent a particular approach to learning and action. But one of the problems appears to be that the essence of the scientific endeavour is not agreed upon; the common ground shared by the many groups using science as a banner does not appear very substantial. Thus, some agencies are associated with what looks like a rather straightforward message of 'science for all', popularising a basic scientific literacy across the total community of a country. Others are asking whose science is being popularised, and what is the impact of particular versions of Western science on local science and technology traditions. So far from school science and out of school science purveying basically the same method and approach, it is noticeable in certain settings that science-based interventions outside the school are in many cases anti-school. They perceive themselves as recuperating the many thousands whom school has failed or excluded; in many instances, the science message out of school is directed to village improvements in health, agriculture and self-reliance, whereas school science, for all its rhetoric of discovery methods, can be caricatured as ultimately concerned with certification and selection, and very little related to societal improvement.

The nature of science in industry and agriculture at the state level is also problematical in many industrialising countries. The relation between the science system in the world of work and the operation of science in school and in various people's science movements is complex, and is made more so by the fact that the national science establishment is itself frequently involved in a set of complicated relationships with international sources of science and technology emanating from the industrialised countries. The set of interactions with which we are concerned in developing countries is ultimately not separable from the impact of science, technology and education developments in Northern industrialised

²Krishna Kumar, 'People's Science and Development Theory', ESPRA paper, New Delhi 1984, p. 3.
countries. However, the main lines of debate in the seminar were concerned with the following relations:

- relations between the science education system and the national valuation of science;
- relations between the science of popular science movements and that purveyed in formal education;
- interactions between transnational systems of scientific knowledge production and local systems.

Cutting across the different levels of discourse, from the rural areas to the schools, and from the schools to forestry science, microelectronics and manpower planning was the notion of an alternative approach or an alternative paradigm with which to make sense of the contradictions in science and in science education. But the search for an alternative was not shared by all. Qualified support for science as the moderniser and transformer of society came from South East Asia, from the 'science city' of Singapore and from South Korea, which attributes so much of its contemporary scientific and technological capacity to the steadfast pursuit of science. Nevertheless, even in these settings where the reign of science and technology was generally unchallenged, there had been unconventional links between scientists and villages (Korea), and at least some exploration of the possibly complex consequences of overinvesting in science (Singapore). In India too, the meeting to some small extent reflected tensions within the wider community of scientists and social scientists about the nature of science in its relations to society; the tip of the iceberg of this extremely serious debate has been evident for two years in the public discussion for and against 'scientific temper'; but beneath this, there is a literature both wide and deep, going back to analyse Indian science and technology in the 18th century, re-examining the different faces of British colonialism in relation to science, re-interpreting Gandhi and the science question, and reviewing the many different shades of the people's science movement. There is also in India, as in any country, the science advisory personnel in government, reacting and formulating policy in relation to the politicians' decisions about technology imports, or protection of existing technologies. Here there is a good deal less latitude for manoeuvre than in the academic community and the private research centres. But yet, the whole sub-discipline of science and technology policy is founded on the belief that there are in many parts of government, decision-makers who at key moments lack the vital information on, for example, the dangers of eucalyptus, environmental degradation, or even the latest research insights on what can be expected of computers in schools. In the absence of such critical data - so the story goes - governments commit themselves often to expensive and unproven technologies, which are frequently questioned or abandoned later on (education TV in the Ivory Coast
is a case in point). We shall note later that the issue is not as simple as whether or not full research knowledge is available on the impact of the new technology. Nevertheless, it is all too common, as with new information technology, for Third World decision-makers to conceive of their countries as having no choice but to introduce a technology that is so markedly affecting the production and service sectors of the OECD countries.

There has been a great deal written on North-South relations in science and technology both before and after the UN Conference on Science and Technology for Development (UNCSTD). Some of this has indicted science and technology for becoming apparently 'instruments of global structures of inequity, exploitation and oppression', through the dissemination transnationally of inappropriate technologies, and the monopolisation of science R & D in military developments. Other literature has focussed on the scope for the indigenisation of originally imported technologies, and on the development and adaptation of local technological traditions. Very recently for example, there has been a move away from the more extreme versions of technological dependency of the South on the North, and a renewed interest in the sources and extent of 'indigenous technological capability'. However, what characterises a good deal of the literature that falls under the broad title of science-and-technology-for-development is that, first of all, it is more concerned with technology than with science; despite the coupling of science and technology, it is the latter that dominates discussion, whether in the accounts of technology transfer, technological change, technological dependency, indigenous (or endogenous) technological capacity, appropriate and inappropriate technologies or in the many recommendations about technology policy in the Third World. Second, whether the analysis of the impact of Western technology has been critical or whether it has been searching for local alternatives, there has been little attention paid to valuations of such technologies by the users and the receivers, or more broadly to the education systems that seek to institutionalise such values. To some extent this has been because the discourse on technology has been dominated by economists very properly anxious to sort out the costs and benefits of alternative technologies, or of free market versus protectionist policies, or of investment strategies that can encourage the indigenisation and adaptation in the South of technological changes taking place in industrialised countries. But it has also been because till recently little attention has been given by education researchers and sociologists to the impact of science and technology both in the formal schools and in nonformal education.


4M. Fransman and K. King, Technological Capability in Developing Countries, (Macmillan 1984).
This meeting was an attempt to look at the value systems attached to science and technology, not just in general, but very specifically in relation to the exposure of the young to science in schools, and of adults to science movements in rural and urban areas. It brought together scholars concerned with the analysis of science in society, as well as those required to make scientific and technological decisions on behalf of their societies. To this extent it combined practitioners in science policy with people practising science-based innovation in school or society, and both of these with people critiquing philosophies of science and traditions of technology. A fruitful dialogue was possible because science education was conceived as something more than curriculum development in science subjects (valuable though that is), and because science policy at the level of the state was seen as something more complex than a strategy about what to promote and how to promote it.

The form of this paper will not follow the order of the meeting, but will explore two main avenues in respect of the analysis of science and technology in society. First, an attempt will be made to examine the extent to which the wider debates about science and society affect the major mechanism for exposing the young to science - the schools and colleges. Second, for the adult population, some attention will be given to the assumptions that lie behind the myriad ventures that seek to offer 'science for the people'. In both these sectors there is, from the meeting, a larger concern about the science message mediated by scientists, science educators, textbooks, media, new technologies, and science experiments. There is also an awareness that the text of science and the codes of technology fall into a divided world. For the purposes of this discussion, the principal divisions are between the OECD industrialised countries and the less industrialised nations of the political 'South', and in the countries of the 'South', between the science and technology interests of the state and large firms in the modern sector on the one hand, and the promise of science for the poor, on the other.

The Debates about Science and School

At one level there is no debate about science and school. In many, perhaps most, countries, science has replaced Greek and Latin in terms of subject status, and to that extent it acts as one of the prime filters to high paid jobs, whether in science fields or outside. Like the classics, science is widely assumed to have a value as an intellectual training, quite apart from the merits of the curriculum content. Beyond this, many would feel that science unlike the classics has a transformationist potential; to many developing countries, science and the scientific attitude seem partly to be what distinguishes the industrialised North from themselves. The scientific mentality is assumed to be diffused widely in the North, and its absence, particularly amongst rural populations, is felt somehow to be connected to poverty and backwardness. Science
appears to have a further advantage over the classics: that it is not apparently so rooted in the cultures of the West as are Greek and Latin. So that although its arrival was often associated with the spread of western influence or empire, it has stayed on in the curriculum long after the departure of British constitutional history.

The above makes it clear that quite apart from the use of science subjects to mark academic success in school, science has been very firmly associated with modernisation in the minds of those framing the curricula of newly independent countries. Investment in science, as in education more generally, would give developing countries direct access to those technologies for which they have been so dependent on the West in the colonial period. Only a truncated version of science had been available under colonialism; now it could be turned into one of the main levers of national development. India's commitment to this faith in transformation by investment in science is widely evident in her post-Independence scientific manpower commissions, and is nowhere more elegantly summed up than in the Kothari Commission of 1966, which reported at the very height of the international consensus about the relation between high level manpower and economic development:

While the development of physical resources is a means to an end, that of human resources is an end in itself; and without it, even the adequate development of physical resources is not possible...

For instance, there can be no hope of making the country self-sufficient in food unless the farmer himself is moved out of his age-long conservatism through a science-based education, becomes interested in experimentation, and is ready to adopt techniques that increase yields. The same is true of industry. The skilled manpower needed for the relevant research and its systematic application to agriculture, industry and other sectors of life can only come from a development of scientific and technological education ....

Education as Instrument of Change. If this change on a grand scale is to be achieved without violent revolution ... there is one and only one instrument that can be used: EDUCATION.

Another illustration of this faith in science potential was the building up often with substantial foreign aid of Science Education Centres, and Science Education Programmes. These developed in countries as different as Turkey, Lebanon, Sierra Leone, Brazil and

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the Philippines, to mention only a few. In a way, they were to some extent a ricochet into the developing countries of the sudden and dramatic funding for maths and science in the West that followed on the heels of Sputnik. But they had their own local momentum, and their pre-eminence served to underline the fact that what was expected from a science centre could not apparently be offered by English, History, Social Studies or other subjects.

Some part of the attraction of 1960s science to the developing countries was that there had just recently been a major paradigm shift in the West in the teaching of science. The new emphasis on discovery methods underlined the fact that students were not to be involved in merely memorising the laws and formulae as time worn as the Latin declensions; they would be operating as apprentice scientists, hypothesising, testing and confirming the results of their own experiments. The student-as-scientist philosophy, and its associated curricula, science kits and materials, appealed directly to many developing countries. Participation in what was thought loosely to be a universal method of the sciences fitted well into the aspirations to pursue active science with the overtones of building up a strong independent scientific community.

The epitome of this universality of scientific method, culture free, cutting across the old divisions between metropolis and colony was to be seen in the international agricultural research centres which were set up from 1960 onwards. They typified the view that pathbreaking scientific research could be carried out in developing countries, and that the results need know no frontiers. An early memorandum on the International Rice Research Institute in the Philippines was characteristic of this model of scientific aspiration. The advantages of a single centre for rice research in Asia was that

a) international, or least multiple-country, cooperation in any field of science is broadly speaking, a good thing. It furnishes a basis for international friendships and understanding, and contributes toward a pattern of global living which is undoubtedly a desirable and necessary part of the future.

b) The basic problems concerning rice are universal problems, which can be properly attacked in one central laboratory which would then make the results available to all. Many of the really fundamental physiological, biochemical and genetic problems are essentially independent of geography and are certainly independent of political boundaries; so that these problems could effectively and efficiently be attacked in one central institute.

The message of the era, whether in schools, in agriculture, or in industry, was that the scientific methods, institutions and procedures were available, and they could be acquired and put to work for any people that was serious about development. South Korea was only one of the more dramatic examples of a nation's ability to buy into science and technology by its deliberate policy in the 1960s and early 1970s of building advanced science and technology capacity. As soon as Singapore achieved internal self-government, it too declared for science, making it compulsory for primary and lower secondary schools in 1959, as part of a wider belief in building up the human capital of the nation. In many countries science became the most powerful expression of the belief in the doctrine of human capital; a science or engineering graduate surely had the potential to assist the nation's economic development in a way that was qualitatively different from a history graduate, a lawyer or a sociologist. From this position, it is a short step to arguing that the country will need more science graduates than arts, and that the ratio should be moved, say, from 60:40 in favour of arts to 60:40 in favour of science. At the apex of the science training system, this kind of favouring of science over arts has not been uncommon in the last 20 years, whether in South Korea or in several parts of Africa. We shall return later to look at the manpower planning side of such calculations, but for the moment it should be noted as just one of a series of measures used to privilege science over arts.

Within a relatively few years of political independence in South and South East Asia, science, a commodity that had been in relatively short supply during the colonial period in the schools, universities and post-graduate schools, was everywhere available, symbolising the nationalist faith in rational change and development via the education system. By the early 1970s, the initial optimism of development economists and planners about rapid economic take-off had withered, and with the exception of the newly industrialising countries (NICs) such as Taiwan, Hong Kong, South Korea and Singapore, it looked as if the science-based investment in human capital was not going to transform societies overnight. We are not concerned here to rehearse the academic critique of human capital theory (which is widely available), but to note its very close connections with the privileging of science in school, university and society. It is however worth remarking that the last word has probably not been said yet on the human capital paradigm, and that few countries really sought to implement it with the commitment and authority of Singapore and South Korea, to mention two of the more obvious examples. Indeed, these and several other states continue

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7For an account see Hyung-Sup Choi, 'The role of various stages of technology relevant to developing countries', Pacific Science Association, Bali, Indonesia 1977.
to invest in different levels of scientifically and technically trained manpower with convictions unaltered by the debate of the last decade and more. Science manpower planning as part of economic planning is everywhere evident, for example in the rationale of the Nanyang Technological Institute in Singapore:

The move is now towards restructuring the economy to high technology manufacturing and computerised services. This includes, among other measures, the expansion of engineering and technological facilities of educational training institutions at all levels to ensure an adequate supply of skilled workers. It is in this context that the Nanyang Technological Institute has been created to play a crucial role.9

It is also worth remarking that whatever the academic hesitations about the assumptions in the human capital theory, the rhetoric of investment in high level scientific and technical manpower is back on the agenda of many nations in the early 1980s. In the wake of the UNCSTD conference of 1979, several countries outside South East Asia are assuming that they gave insufficient attention to the science investment paradigm, and if they wish to join the 'science club', they had better invest more rather than less in science manpower.10 Indeed there is now some evidence to suggest that donor agencies in the West, so far from despairing about scientific and technological investment strategies are returning more soberly to a version of the same human capital theory, in approaching the role of science and technology in relation to higher education.11 Possibly part of the same fascination with science potential is to be seen in the widespread interest in developing countries in participating in the current international evaluation of science achievement in schools orchestrated by the International Association for the Evaluation of Educational Achievement (IEA).12

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10 See further K. King, 'Some conceptual issues in scientific and technological manpower', ESPRA paper, New Delhi, 1984, p. 3.
11 It is interesting to note that the former deputy minister of Science and Technology in South Korea has been acting as consultant to the World Bank in this very area of higher scientific investment. See Hyung-Ki Kim, 'Some basic elements in the development of scientific and technological infrastructure in developing countries', discussion draft, Washington, January 1983.
12 The IEA second science study is being coordinated from the Australian Council for Educational Research, P.O. Box 210, Hawthorn, Victoria, Australia, and included some 40 participating countries as of September 1982.
Thus far, in examining the course of the debate, we have emphasised some of the rationale employed by countries continuing to back a version of the human capital approach through manipulation of science and technology in the formal education system. There is however a growing constituency concerned about the exposure to compulsory science, and about the increasing schemes for universalising schooling with a major science component. Some of this literature critical of science is not explicitly concerned with science as purveyed by schools and universities; in fact it is significant how little of the wider critique of science and technology in society has been applied to school and university roles in the reproduction of attitudes and competencies in the disciplines of science. We shall look now more closely at the implications of the critique of science for schools, and also at some of the conceptual and practical problems thrown up in the pursuit of 'discovery' science, compulsory science and compensatory science.

The Critique of Science in School and Society

We have remarked earlier on Bernstein's point that the activity and discourse called school science is very different indeed from science in society. Yet, the science teaching paradigm of the last two decades and more has been based on the opposite assumption: that the pupil through discovery methods 'could think about scientific things in the way that practising scientists do'. In the British context, David Layton very appropriately makes the point that this approach makes some large and rather questionable assumptions about scientific activity, and particularly its apparent separation from society:

... only on the basis of the most superficial analysis of the nature of scientific activity, could it be said that such methods (discovery) enable children to think and work in ways characteristic of a successful practitioner of science ....

The view of science which informed the original Nuffield schools science project and the American study projects, was "science as search" and in so far as these courses were concerned to put children in the position of a scientific inquirer after new knowledge, the stereotype was that of the pure scientist, supremely oblivious to the applications and wider implications of his work. Science was studied as an end in itself.14

Apart from these fundamental questions about the nature of scientific activity, it also became rapidly obvious that discovery

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14 D. Layton, op.cit., pp. 175, 177.
methods required a great deal of equipment if individual students were really to 'discover' things for themselves. So the technology of discovery science proved costly, and when discovery science was exported to many parts of the newly independent Third World in the 1960s, it became apparent that there were high costs associated with the materials and kits required for discovery. The textbooks also insisted on discovery by offering no answers: 'Now, what is happening? Write down a hypothesis or possible explanation of what you see.' Paradoxically, this could make the pupils more teacher-dependent in situations where insufficient materials or time meant that the teacher alone did the experiment, gave the notes, and where the textbook could not be used for revision.

Little work has been done on this, but it seems likely that discovery science with all the paraphernalia of kits, materials and educational technology was even more attractive in some ways to new nations who could interpret it as a chance to participate on an equal footing with the earlier industrialised countries. There was then and continues to be now a very lively concern about the creativity of the Third World scientist, and about the tendency for dominant theory and technology to derive from the North. The interest therefore in embracing discovery science is ultimately not dissociable from the wider concern, expressed so eloquently by J.P.S. Uberoi, about the role of third World scholars in the generation of new theory, and the problem of deviating from the Western 'scientific' paradigm:

I am .... expected by my colleagues to confine myself within the duly certified professional sociological theories of modern times. In that even, the chief things to say are

a) that such ruling theories, as I should call them, have all come out of the West; and

b) that the West alone remains the sole authority in charge of them.

By this definition, the non-Western world had lost the battle for theory, so to say, before it even began, and we can now only either do empirical work in India in the light of imported theory and method; or waste time and effort in complaining that borrowed concepts will not fit. ....

At any rate ... all other non-Western or non-modern ideas, theories and methods are definitely ruled out of court from the start as "unscientific" systems of faith and belief rather than rational knowledge and as therefore unworthy of serious refutation; let alone any higher consideration. By the application of such means it is made to seem that there is only one kind of science, modern Western science, left to rule in the world today .... The rest is charmingly called "ethnoscience" at best, and false superstition and darkest ignorance at worst.15

Discovery science, itself a discovery of Western curriculum developers, is a small example of Uberoi's point. It became the new orthodoxy very rapidly in a number of developing countries - but by no means all. Just as the original ideas emerged from the West so did the growing critique of those assumptions. In this respect new science appears to have been somewhat different from new maths; the latter attracted eventually very powerful criticism in many developing countries, and was in some scrapped by presidential decree, as being allegedly unsuitable to developing countries. Whereas the criticisms and compromises with the new discovery science approach were certainly very evident in the countries of origin. In many quarters, however, the nature of the criticism was more concerned with practical issues (the cost of associated materials) and much less with the question of the kind of science that was on offer. From the point of view of this paper, it would seem that science educators have paid insufficient attention to questions about the nature and impact of the science being taught, and for this reason there is still too little interaction between the literature on science emanating from science studies centres and the pedagogical discourse about science education in schools. Some examples may be useful in pointing to issues that go beyond the narrower interpretations of science curriculum development, and which if given attention by curriculum specialists could influence the very way science is approached.

One potentially rich vein of research lies in the exploration of the intuitive belief systems that students bring to school. So far from the student as an apprentice, 'pure' scientist discovering for himself or herself new insights, the available data on students' intuitive understandings of phenomena opens up exciting visions of cross cultural work across the North-South divide, and might even be taken to suggest that a form of 'ethnoscience' is not something that begins South of the Mediterranean, but is a common experience of students in school and university whether in Japan, India or Britain. In a recent review of literature on this 'other science', Rosalind Driver and Gaalen Erickson note the range of key concepts in physics where students have their own intuitive beliefs at odds with 'official' teaching in dynamics, gravity, heat, light, density, particulate theory, electricity, air pressure, to mention only a few. They comment on a major shift again in the school science paradigm:

Until recently the major emphasis in the development of most school science curricula has been directed towards the structure of the knowledge to be taught. However, there is now a growing interest in the notion that students do possess "invented ideas" based upon their interpretations of sensory impressions which influence the ways in which they respond to and understand this disciplinary knowledge as presented in the classroom. Evidence for the claim that students have intuitive ideas about natural
phenomena abounds in the now extensive journal literature

These student frameworks often result in conceptual confusion as they lead to different predictions and explanations from those frameworks sanctioned by school science.16

In India, Anita Rampal has come to a similar conclusion, realising that the implications for teaching science are very major. She argues that for pupils to shake the alternative frameworks they have built up over the years requires almost the kind of paradigm shift that from time to time has occurred in the history of science itself. The analogy with the history of science is not fanciful, for she discovered even in the most reputed public schools of New Delhi that at the end of secondary education 'pre-Newtonian beliefs regarding force and motion seem to hold sway and that the quality and level of instruction appear to have no significant effect on the extent to which these beliefs are held'.17

There is another aspect of these larger questions about the kind of science paradigm to which students are exposed. For all the talk of discovery science and the encouragement of heuristic methods, there is considerable evidence that schools spend most of their time in science introducing students to the established knowledge and traditions of science rather than to any sense of debate or controversy. In this tradition which equally affects schools in the North and the South, discovery really means finding out the answers that everyone already knows. In the North this is done by 'experimental' verification in laboratory work, in the South very often the codex of science is acquired directly from texts and exam guides without going through practicals and demonstrations. But there is probably more to this preference for proceeding directly to the codex than merely the expense of laboratory materials, oversize classes, and the relative inexperience of teachers in making lab work produce the 'right' answers. In several countries, for example, Singapore, and possibly other East and South East Asian nations, the tradition of deference by the disciple for the master runs through the social relations of schools, and is directly counter to a strong pupil-centred curriculum, even if discovery and inquiry methods are often in reality simply more labour-intensive forms of verification science.18 In this sense, science education can become doubly authoritarian, both in its tradition and in its pedagogy conforming to Kuhn's description of it as 'a relatively dogmatic initiation into a pre-established problem-solving tradition that the student is

17Anita Rampal, 'How tenacious are intuitive beliefs in the process of learning science?', ESPRA paper, New Delhi 1984, p. 1.
neither invited nor equipped to evaluate'.

Science and Values in the North and the South

What tends to be missing throughout school and even college science is any sense of controversy either about the nature of science or its social implications. Clearly it should make a great deal of difference to the whole science teaching enterprise if there are questions about the very paradigm on which science is currently based. If, for example, the claims that modern science is value-free, objective, and epistemologically superior cannot be sustained satisfactorily in any examination of the role of science and technology in society, then something of this tension should express itself in the pedagogy. There are several dimensions of these conflicts between the nature of the scientific enterprise and the view of that enterprise as promoted in schools.

At one level there is simply the tension between the complex and often provisional nature of scientific knowledge in a particular field and the material offered in school texts. Arguably, in this respect science is no different from history or other subjects where school versions dramatically oversimplify human motivation or the role of the communities, classes and nations. Yet in science, there is a difference for it is assumed that the basic propositions of science in the lower secondary school are not provisional, or diluted versions of some later complexity. A rare illustration of this is provided by the remark of a Scottish science teacher recently that 'most of what is taught in school chemistry is white lies' when compared with the controversy about the most basic principles of chemical bonding that goes on in tertiary education. These and other aspects of debate are generally excluded from the text of science as presented to schools, with the result that the other face of science is not on view at all. In this respect, as Paul Feyerabend argues, science education performs a dangerous dis-service by objectifying and simplifying the history and method of the sciences:

Now it is, of course, possible to simplify the medium in which a scientist works by simplifying its main actors. The history of science, after all, does not just consist of facts and conclusions drawn from facts. It also contains ideas, interpretations of facts, problems created by conflicting interpretations, mistakes and so on .... This being the case, the history of science will be as complex, chaotic, full of mistakes, and entertaining as

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20For an example of the conflict in 'scientific' values outside the schools, see Vandana Shiva, 'Government science and environmental action: the case of forestry in India', ESPRA paper, New Delhi 1984; the basic question about the validity of the text of science was posed also by Farzam Arbab in the ESPRA meeting.
are the minds of those who invented them. Conversely, a little brainwashing will go a long way in making the history of science duller, simpler, more uniform, more "objective" and more easily accessible to treatment by strict and unchangeable rules.

Scientific education as we know it today has precisely this aim. It simplifies "science" by simplifying its participants.\(^{22}\)

At another level, there is the potential for bringing out into the open the conflict to which we have already alluded between intuitive beliefs about science and the received wisdom of science (the latter itself affected by the qualifications of Feyerabend and others).

But at a much more general level, it should be possible for science educators and philosophers of science in developing countries to produce materials that reflect the distinction between the highly western origins of western science and technology on the one hand and the possibility of becoming scientifically developed without necessarily becoming like the West. This means becoming much more explicit about the way in which the sciences are 'parts of each culture's much wider system of experiencing nature and making sense of it', and are therefore intimately affected by the ideological role of science in that particular society.\(^{23}\) If it is once admitted that the allegedly universal science subjects are in fact as peculiarly western as British constitutional history is British, then very major questions are raised for the science curriculum development communities in the Third World. In many, perhaps most cases, these communities have been willing parties in the import and repackaging of American and European approaches to the study of nature, in some countries using the very textbooks of Europe and America. There is no doubting the difficulty of developing in the face of such powerful opposition, fully developed sciences that will bear the marks of India or of China's rich and complex scientific past and present. One reason for the difficulty is presented by Sivin; American and European approaches have 'spread round the world' not because they provide 'the only conceivable basis for organising contemporary scientific work, but because the encounter between traditional and modern science in one society after another has been resolved by social change and political fiat, in view of which the comparative appropriateness of each system of science to the cultural environment is beside the point'.\(^{24}\)


\(^{24}\)Sivin, op.cit., quoted in Anderson and Buck op.cit., p. 228.
Despite this, it is probably now the case at least in India that research literature is available on the history, philosophy, sociology and psychology of Indian sciences to a degree that would allow the articulation and development of alternative science approaches. Work associated with Ashis Nandy, Dharampal, Rajni Kothari, Claude Alvares, to mention only a few names among many, could have a direct potential for translation into a very different set of science texts than the present.25

But at the moment, it must be admitted that with exceptions to which we shall shortly turn, the science education texts give no flavour of any such alternatives, so rooted are they in the traditions and even the passing fashions of Europe and America.

The development of culture-dependent science frameworks in India or other countries implies a good deal more than what passes in the science education community for 'indigenisation'. This has often meant little more than Indianising the examples and illustrations in what remains an unchallenged set of assumptions about the nature of scientific knowledge and its current specialisations. For all the rhetoric about indigenisation in both national and regional science meetings, it is appropriate to question with Dean Nielsen whether 'after so many years of indigenous curriculum reform ... there are any true examples of an indigenous science curriculum in South East Asian schools. Adopting an activity-oriented, discovery-based science is a significant reform, but in a sense it is simply exchanging an old imported model for a new one.'26 Presumably one of the reasons for the lack of significant moves in developing alternative science frameworks in school texts in India is the view that there really is not much scope for 'localising' sciences as compared with social studies and social sciences. At Independence therefore in most ex-colonies it was history and geography that were indigenised, whilst the sciences received only minor adaptations. The widespread view that the sciences were culture free, and that Indian or African science was a contradiction in terms, underpinned these merely cosmetic changes in science education. More recently, however, it has been felt that such re-thinking is essential not just for pedagogical reasons. But much more importantly, it can be suggested that such re-thinking is inseparable from any true popularisation of science, and may be an essential preconditon for substantial innovation and creativity to take place in the Indian science community. Even satisfactory

25See amongst much else, Dharampal, Indian science and technology in the eighteenth century (New Delhi 1971), and The beautiful tree (New Delhi 1983); Ashis Nandy, Alternative sciences (New Delhi 1980), and The intimate enemy (New Delhi 1983); Claude Alveres, Homo Faber: technology and culture in India, China and the West – 1500-1972 (New Delhi 1979).

borrowing of new technologies must be predicated upon a widespread understanding of the history and values of some such local science framework, as Dharampal concludes:

The problem of India today, as perhaps for many other lands which are still recovering from the effects of eighteenth and nineteenth century European dominance, is how to achieve and increase such innovation and creativity. Such innovation and creativity can however arise only from a widespread indigenous base. Such a base has yet to be identified ... in countries like India. For that, knowledge and comprehension of how they (science and technology) functioned before the beginning of this dominance seems to be essential. Even for the purposeful adaptations from European (or for that matter Japanese, Chinese or any other) science and technology and the integration of these with the more indigenous concepts, knowledge and forms it is necessary that these countries achieve such knowledge and comprehension at the earliest.27

A last aspect that relates equally to science in education and science in society concerns what has been called loosely value-oriented science. The very term is a welcome admission that science cannot be excluded from the controversies and ideologies of society, as a monastic discipline pursuing its own routines in the purity of its withdrawal. The penetration of society by science and technology has been so comprehensive that the pursuit of disciplinary purity in the sciences is easily challenged. Nevertheless, as with the issue of indigenisation there is a great variety of positions taken in respect to science and values. There is, first of all, as with so much else the import to the Third World's science courses of a new concern in the West about relating science in some way to societal issues. Typically, science-and-society courses which discuss problems of pollution, energy, medicine etc. are targeted at those pupils deemed less able to deal with the academic pursuit of chemistry, physics and maths. In this sense, science-and-society courses are used to make science more interesting to those who are classified as the future consumers of technology. At their worst, they stress good shopping habits for the young adults; at best presumably they can constitute conscious scientific literacy, and an awareness of the inescapable controversies at the heart of developments in science and technology. The suggestion however that science-and-values may be useful for the consumers and not the producers of science and technology is a worrying conclusion from the way such courses fall into the hierarchy of scientific knowledge. In this connection it is interesting to note that in Singapore students who follow the less academic science subjects (such as Human and Social Biology, where it might be assumed science

27Dharampal, Indian Science and technology in the 18th and 19th century, op.cit., p. 54.
and values might be discussed) are termed 'sub-science' or 'arts' students.  

Apart from the strand of science-and-values that is associated with established trends in the West (see also UNESCO's current priority on science and the environment), there appears in a number of South East Asian nations to be a growing interest in a science education more related to ethical concerns, and in a greater social accountability for scientists and technologists. At the moment it is doubtful if much of this has affected the schools, and unclear how it would affect the much more powerful value system that underpins the way sciences are taught. There is however becoming available material such as The State of India's Environment: a Citizens' Report which would allow science curriculum developers to see that the issue of science and of values is not 'how do we somewhat humanise the sciences', but 'how do we get popular discussion on the values that are part and parcel of the western science and technology package?'  

Our growing capabilities in science and technology have helped us to acquire a technological literacy that allows us to converse with the rest of the world as equals and has rightly earned us international prestige amongst the community of nations. But science and technology cannot be allowed to impose their own value system on society. On the contrary, the use of science and technology in society has to be governed by a human, socially appropriate value system.  

One tentative outcome from the discussion about science education and values is that thus far it is very muted in the formal school and college science situation, but much more openly on the agenda of popular science movements, science journals and science fora. The majority of science teachers are ill-prepared, and probably disinclined to treat science as having a direct 'association with specific controversial issues which call into play children's discriminational and judgemental powers.' We have however already implied that conflict in values lies full in the face of any attempt to build context-dependent science frameworks, since such frameworks will directly challenge the legacy of Western knowledge organisation. Hence value conflicts lie at the heart not only of the pedagogical  

28N. Tang, op. cit., p. 3.  
31D. Layton, op. cit., p. 184.
organisation of science knowledge, but its application to society.

Possibly one reason why non-formal science education can reach more rapidly the issues relating to the roles of science in society is precisely because it has the freedom to redefine the organisation of scientific knowledge in ways that formal schools feel unable to contemplate. Thus, the Rural University in Colombia was able at the outset to critique existing knowledge frameworks in science in developing its own organisation of knowledge:

The way a western university is organised in departments dealing with defined disciplines is as much a reflection of a style of life, of a social ideology, and of historical realities of a people, as it is of a convenient division of knowledge to be grasped by individuals of different talents and inclinations. Therefore, when a population establishes within itself an education system with such a structure, it is buying more than knowledge; it is making definite statements about its future social organisation.32

Becoming aware of the social consequences of how scientific knowledge is organised is an important first step in sorting out the values of science. And even if building a different and more appropriate framework for science may appear an impossibly long term - even utopian - goal, the very awareness of the need can lead to the teaching of science in new and unconventional ways. One detailed account of such a development is contained in the history of FUNDAEC, the rural 'university' in Colombia referred to above, and doubtless other detailed narrative can be found in India, such as the Hoshangabad Science Teaching Programme.33

It is possible that there is a great deal more alternative science being taught within the formal schools systems than we presently think; a good deal more school level research would need to be pursued to be certain. But, subject to such further research, it presently looks as if in a country like India the real questioning of science and technology values is going on in the informal or non-formal science movements. Tethered by examinations and reinforced by the status rankings for science subjects imported from the West, school and college science presents a very different face from the science activists in the popular movements. It is in the latter that there can be found the social and political controversies about science so necessary to any far-reaching indigenisation of science.


33F. Arbab et al., Fundaec: an experience in rural development (1983, mimeo, 118 pages); for Kishore Bharati and the Hoshangabad Programme, see K. King, 'Science, Technology and Education Research' op.cit.
... writers on the development of science and on science and development might consider drawing a lesson from the history of science in the West. Instead of worrying about how to keep knowledge politically and ideologically chaste, they should be wondering how to make scientific theories and concepts into objects of social and political controversy in developing societies. Were that to happen, then science would be well on the way to escaping from the kind of sterile academicism which besets so much research in so much of the world. More importantly, science might then take hold of the people of the Third World, and they might take hold of it.3

We shall return to the point later but at the moment it looks as if, in parallel with what has happened with much of the political activism in India taking place outside the established political party process, the rethinking of science and technology has begun outside the mainstream of institutions charged with the compulsory instruction in those subjects.

Before coming to look at the nature of this other science and technology being promoted in various forms of popular education, there is a strain of unconventional science being attempted within the formal school and college system. This unconventionality is less concerned with rethinking the nature of science, in the manner we have discussed above, and more alive to the consequences of compulsory science within national school systems. One consequence of compulsory science being introduced into the increasingly universal education systems of the Third World is that very large number of first generation learners experience science as the archetypically difficult subject, in which they most easily fail. There is little doubt that in many countries science now does play the role of selector of talent, to the extent that in some situations children identified as intelligent by their teachers are not allowed not to specialise in science. An illustration of a school system organised around this assumption is Singapore where streaming by ability in the New Education System is practised from the third year of schooling. One logical outcome of using science to distinguish success from failure is that it has been recently decided that for the lowest 40% of the ability range, it will no longer be necessary to pursue science in secondary school. It must be admitted however that what Singapore makes explicit is just as often the outcome in countries that maintain the rhetoric of equal access and equal opportunity, and even, in the case of India, make special educational provision for the 'weaker classes' of society. The net result of the schooling-for-all, or science-for-all slogans is that most do not achieve meaningful schooling or an insight into science. Whatever may be said about science popularisation for society, the schools' interpretation of

Science keeps it strictly within an elite stratum of knowledge, hedged about by complex language and procedures.

Centres such as the Homi Bhabha Centre for Science Education (HBCSE) have shown convincingly in the face of massive drop-out and school failure by the weaker sections of society that what has traditionally been considered as science failure has more often than not been failure to deal with the complex language in which science is presented. The simplification of the surrounding language has allowed access to the science, and the natural curiosity of students about natural phenomena has not been stifled by use of artificial linguistic barriers. The same was found to be true of the symbolic language of formulae, graphs, equations and drawings in which so much science and maths is couched; students were failing in the languages in which the sciences were mediated, almost before they had any insight into the content of science.\(^3\)

Perhaps partly derived from this concern to allow students direct access to question-raising about natural phenomena has been the interest in India, and in other countries in providing schools with science kits. These deserve research study in their own right for they can be taken as a microcosm of the larger attitudes to scientific experience in schools. The more complex electronic project labs commercially available in the West offer to children high quality packaged kits with manuals describing 200 or 300 attractive ploys or 'experiments'. The very titles indicate that the barrier between play and study is under attack: sonic zoo and sound factory; electronic elephant; burglar alarm; electronic roulette etc. One of the commonest of these 200 in 1 science fairs turns out to be made by the US multinational, Radio Shack, a division of Tandy Corporation. At the very opposite end of the kit spectrum are those associated with HBCSE, which at a twentieth of the price stress local materials, open-endedness, and are as unpackaged as a kit can be:

The basic philosophy is to demonstrate that educationally relevant and intellectually satisfying activities can be conducted using material readily available in one's neighbourhood. However, such a philosophy does not work in a vacuum. Making available a seed around which growth is possible can achieve very good results. The teachers in this project have multiplied the contents of the kit several fold.\(^3\)

But with kits, as with textbooks, and science laboratories, it would seem that they can both reflect the existing science paradigms, or be used to raise questions about their operations. Often it

\(^3\) V.G. Kulkarni, 'Universalisation of education. Problems and remedial measures', ESPRA paper, New Delhi 1984, passim.

\(^3\) Kulkarni, op.cit., p. 23. See also K. King, 'Science, technology and education research in India', August 1982; and Nielson, op.cit., pp. 7-8.
seems that the educational technology side of kits is stressed to the exclusion of any exploration of the code or the assumptions about science that are implicit in the kit. For example, the science kit in the West suggests that some form of science can leave the lab and be taken home. Most commonly in developing countries, the kit is not so much a supplement but the only source of certain materials in the poorer schools. The very process of deciding what are the minimum essential learning needs for tens of thousands of schools offers a fascinating insight into lowest common denominator science priorities. The kit therefore encapsulates an integrated set of assumptions about what must be experienced through doing, and what must simply be learnt. It would be surprising in this situation if there were not a series of compromises between what can satisfactorily be kitted, and what cannot, even though the latter may be regarded as essential.37

Similar questions could be raised about the role of labs. What really determines what can be learnt without any practical, what is best demonstrated by the teacher to the whole class, and what is preferable for the students to do for themselves, either individually or in groups? Often it appears that such questions are decided by such practical matters as availability of time, imminence of exams, teacher competence, presence of technician support, or the choice of particular 'discovery' textbooks rather than what it is about a particular part of the codex of science that needs visualisation or experience. It is also obvious that there are intriguing differences within physics, chemistry and biology in the extent and type of lab work, use of controlled experiment etc. Some of this appears to have as much to do with the very different traditions in the different sciences as it has to do with pedagogical theory about practicals or discovery learning. Equally, the highly theoretical approach to physics and chemistry in the People's Republic of China, and to some extent in South Korea and Singapore may, we have suggested, point to a good deal more than the lack of labs, or exam orientation; it may suggest that sciences are built upon a somewhat different organisation of knowledge than that in Europe and America. Such issues would be worth exploring in a little more detail as Korea and China are currently being drawn, partly through aid moneys, into patterns of science exposure more common to western schools and universities. Such research would be important, not only because of what has been said about alternative science frameworks, but also because at $350,000 US a time, fitting out a single lower secondary school's science laboratories is not cheap.38

37For some of the most innovative thinking in relation to school science kits, see Hari Parameswaran's science kits, and his paper 'Creativity and children', ESPRA, New Delhi 1984.
38This is the current price in Singapore; see N. Tang, op.cit., p. 14. For some of the controversy about learning and science labs, see research reported in Nielsen, op.cit., pp. 20-21.
Much of the concern with labs and kits has been derived from desires to compensate science in the Third World for the absence of the richer science environment in the West both in school and outside. Also within the developing world, kits and local forms of discovery science have been utilised to compensate disadvantaged groups and put them on a more equal footing in competing with traditional learners. The most successful interventions of this sort have however not so much been questioning the existing school science paradigm, as preparing weaker sections of society to succeed where failure has been traditional. Challenging conventional expectations for lower caste children possibly made it essential, in the first place, to demonstrate that such children could succeed in the same race as middle class students, more especially when certification is only available from following identical courses to those in the ordinary state schools.\textsuperscript{39} To some extent, therefore, the political necessity for lower caste children to succeed in the same contest as other children means that the most exciting initiatives in school science alter the pedagogy more than the paradigm, whereas in out of school science movements both the pedagogy and paradigm are being challenged.

One final example may be useful for exploring somewhat further the North-South interplay of values in science which bears very directly on the two aspects of compensation with which developing countries are concerned: catching up with the North, and allowing the rural and poorer urban areas to catch up with elite schools in the cities. We have stressed that in the absence of explicit alternative frameworks for science in developing societies, the tendency when presented with major innovations from the North is to seek to absorb them, as part of the evidence of 'becoming modern'. By far the most visible of the science-related innovations of the last several years is the move to introduce computers into schools, at both primary and secondary level. The claims made by those promoting these go far beyond the use of the computer as a tool to aid certain kinds of calculation or reinforce learning in the manner of the older computer-assisted-instruction. It is suggested that the interactive learning now possible can make for qualitatively different cognitive experiences in school and home. Advocates of the experience have particularly emphasised the impact on mathematics and on science, and so closely have OECD countries regarded these investments in schools as impinging on national capacity in new information technology that few governments have hesitated to subsidise national suppliers to aim at the school market. At American universities, an even fiercer battle is being fought out by the main microcomputer manufacturers to supply, free or at highly subsidised rates, their products to professors and students. Already four universities have declared that students must bring computers with them as a precondition of entry, and Carnegie-Mellon confidently expects to have 7,500 personal computers by 1986, outnumbering students and faculty.\textsuperscript{40}

\textsuperscript{39}Kulkarni, op.cit., p. 27.

\textsuperscript{40}'Computer firms battle for hearts and minds', New Scientist, February 9, 1984, p. 23.
in teaching, research and in the organisation of learning are claimed to be imminent, finally transforming the labour-intensity of education in ways analogous to office automation, 'paperless' banking, and computer-aided design and manufacturing.

When clearly so much is expected from large scale investments in computers in schools in the West, tremendous pressure is generated in many Third World countries to follow suit. When the rhetoric is all about the educational counterpart of the new information technology revolution, it must sound to many planners and politicians that the technology gap (and allegedly the educational achievement gap) is going to be widened dramatically.\textsuperscript{41} Even more troubling, this new information technology in schools is claimed to be fundamentally different from the older world of audio-visual extras, which were always sold as aids or supplements to learning. The new technology is projected as a new way of learning, but like many technologies it already has a context and code built around it, and these reflect the present state of this technology in the West. Any Third World country buying into new information technology for schools has to be aware of this wider packaging, the main elements of which are:

- the introduction of computers in schools is inseparable from the massive marketing of personal computers into homes;

- computers are multipurpose, and can be used for video games as readily as for more educational uses. The availability of the leisure software has sweetened the introduction of the technology in home and school, and has allowed nonformal learning at home and from peers to support the formal use in schools;

- the availability of tapping into phone and radio networks, TV networks for information and for leisure software by home and school owners of micros, dramatically extends the functions of the technology, as does the ease of machinery for copying, replaying and swapping software with other users;

- the modelling and graphics options of the new technology are all based on the universality of colour TV, or colour monitors in the West, and these in turn linked in almost a quarter of all homes in the U.K. to video recorders;

- the availability of up to 200 computer magazines

\textsuperscript{41}K. King, 'The pursuit of science manpower in the 1980s: conceptual problems', ESPRA paper.
for amateurs to professionals, and a mass of
do-it-yourself manuals and books in the chain
stores of the West;

- some hardware (e.g. Zx Spectrum) and the software
are available at prices which even schoolchildren
can afford if they have saved a little money.
Swapping and 'pirating' mean that whole software
programmes change hands amongst school children
for as little as forty pence (a dollar).

This is the wider 'text' of computers in schools, and it
implies that a Third World country may not get the same result
from concentrating on the school end alone, since the commercial
and home applications may be missing. It also suggests that
in the absence of cheap, reliable and widespread phone, radio
and TV coverage, the multiplier effects of the new technology
will be missing. Furthermore the cheapest hardware is a week's
wage in the West and the software perhaps two hours of adult
work, compared to several months or several days respectively in
many developing countries. All of which means that a handful
of microcomputers in schools may have a good deal less impact
than their counterparts in the West. Compared to the relatively
large numbers of microcomputers in secondary schools in the West,
and the possibilities of doing class teaching with a bank of 10
to 15 micros each offering different programmes, it is much more
likely that schools acquiring these in developing countries will
have sometimes only one or two, and consequently will tend to
treat them with caution.

Nothing that is said here or in other fora is likely to halt
the march of new information technology into the schools of
Thailand, Singapore, Korea and India; indeed in several of
these, computers are part of the school furniture, and in others
major pilot experiments have been agreed. But, as in the West,
decisions are being taken on the introduction of the new
technology with little or no research evidence. Countries that
are attracted by the potential of science and technology to
transform society will tend to see this particular technology as
offering an option that cannot be refused. The more difficult
issue for social scientists, and educators concerned with science
and technology, is to reach some judgement about the impact of
this technology. Again, as with kits, labs etc., it is not
simply a question of affordability, urban-rural contrasts in
availability, indigenous technological capacity versus imports,
important though all of these are; from the perspective of this
paper, it is also a question of whether the knowledge production
associated with new information technology fits into, or can be
adapted to the knowledge and technology traditions of another
society. In many societies, this must seem an academic question,
but in countries like India where there is a highly developed
awareness of technology traditions, and where contradictions in
tradition are obvious in architecture, medicine, forestry and other disciplines, an analysis could be developed in the area of new information technology that drew upon these alternative frameworks in science and technology. Although there are still very few analyses of the impact of NIT in Third World schools, there has already been an outpouring of literature on the phenomenon in the West, to a point where one of the most recent reviews of the subject (David Hawkridge, New Information Technology in Education, London, 1983) has no less than twelve pages of relevant bibliography. But as we have implied, the task for developing country scholars concerned with the technology involves sorting out the way NIT is situated in the wider Western communication systems from the meanings and relevance it could have in urban and rural India. If such a critique is to have any influence on policy, it needs to be carried out before major decisions are taken to commit resources to the new technologies. This then implies that Third World scholars need the opportunity to review emerging technology in the industrial heartlands of the North, if a view about their suitability is to be developed before the almost inevitable pressures for adoption arise from politicians and commercial interests. In such an endeavour, there will be some merit in examining traditions in the North itself which are critical of the social and political implications of new information technology. The problem however for linkages between alternative traditions in the North and South is that the available literature is much harder to locate, and tends to be submerged in the advocacy and promotional writing on new information technology.

Science for the People, People's Science, Science Popularisation

Throughout this paper we have from time to time alluded to the existence of groupings concerned with science which operate outside the formal classrooms and labs on which we have been focusing, and we have implied that such groups may well be able to act in ways that are not so directly affected by the patterns and paradigms that so dominate the regular education systems. Alternative frameworks and conceptualisations of science may be more likely to arise in such nonformal settings than in the certified science of school, college and government research laboratory. When science moves from the world of specialised disciplines, journals, and mission oriented research on space satellites, new technologies etc. to the world of 'science for villages', people's science movements, or 'engineers for rural well-being', what happens to the context of science? Earlier it was suggested that under the popular science banner a considerable variety of different pressure groups find a home, and it may

42 Examples of the search for such frameworks are to be seen for several disciplinary areas in the Patriotic and People-oriented Science and Technology Bulletin, Madras, vols 1-3.

43 See however 'Information technology: a socialist analysis' in Science for People, no. 53, 1982; and The Techno-Peasant Survival Manual: the book that demystifies the technology of the 80's, (Bantam, New York 1980).
be timely since the union of 'science' and 'people' is taking so many forms - even linguistically - that some clarification of the partnership be undertaken.

First it may be useful to distinguish some aspects of popular science in the Third World from the anti-establishment science that has become commonplace in the West. The latter usefully consists in setting scientific expertise against the establishment's scientific expertise, whether in the sphere of pollution, radiation, food, health or environmental issues. Typically the science-based pressure group (such as Green Peace, Friends of the Earth etc.) contests the scientifically attested safety of or need for a nuclear power station, hydro scheme, drug or dumping arrangement; science is thus set against science, and in the process it becomes clear that scientific judgements are controversial. Unlike the mainstream science of school, much of the activity involving pressure groups opposing big business or government makes it clear that science is intimately affected by politics, that science expertise can be arrayed on diametrically opposed political issues. It is interesting also to note that the very subjects that receive so little attention in school science (pollution, environmental degradation, agricultural chemistry, drugs and health) are at the heart of science controversies after school. The courses relating to such subjects are only offered to weaker students, and are seen as inferior to the allegedly purer disciplines of physics and chemistry. Of course, contestations between government science and environmental science lobbies occur also in developing countries: indeed, a classic example is that over eucalyptus in India waged between the eucalyptus lobby (with support from pulpwood users, Forestry Department, government research and even external aid) and small groups of researchers concerned with the scientific study of indigenous systems of farm forestry. One feature, however, that distinguishes groups in the North is that while some run across party lines, a number are explicitly marxist or socialist, and this in turn defines relationships with the constituency they seek to involve and work for. Thus the British Society for Social Responsibility in Science (BSSRS) naturally defines 'people' as the labour movement:

BSSRS is a group of scientific and technical workers in industry, hospitals, education and research establishments. We believe that science is not neutral and cannot be separated from politics. It both reflects and helps determine the value of society. Hence to change the social role of science it is necessary to change society. We are committed to fighting for the use of science and technology by and for the benefit of working people, to demonstrating the political content of science and

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44 See V. Shiva, 'Government science and environmental action', op.cit., also V. Shiva, 'The ecology of eucalyptus', ESPRA paper; see also, Centre for Science and Environment: The State of India's Environment, op.cit., ch. 3, 'forests'.

technology and to furthering the links between scientific and technical workers and the rest of the labour movement. \(^5\)

We shall note by contrast that in India in particular the various expressions of people's science tend to be part of a wider non-party political process in the rural areas.

Before turning to examine grassroots popular science movements, it may also be worth noting the popular science aspect of science centres and science museums. These certainly see themselves as very different from the mainstream science curriculum of schools, but whether they are really working from an alternative conception of science and technology is debatable. What is clear is that museums and science centres are going through a paradigm shift, away from the passive display of objects and inventions in glass cases to an active involvement in the discovery (or more accurately rediscovery) of scientific principles. In that process, whether in the Exploratorium of San Francisco, the Exploratory in Bristol, or in the Community Science Centre in Ahmedabad, young people and adults are urged creatively to question their sense perceptions, to get behind illusions to the principles that make things work. Although museum planners see such activities as being popular science, there is still some sense in which community science centres face school-like problems. For one thing, their hands-on approach to perception, reflection, mechanics, hydraulics, etc., is the same principle at work as the schools desired with their discovery learning, but if the schools found that practical discovery learning interfered with the demands of theory and of exams, science centres may find the opposite, that the practical gadgetry for demonstrating the principles become ends in themselves. In addition, permanent user-friendly practicals are expensive to create and maintain, and it is no accident that such science centres are much more commonplace in America than in Europe, and in Europe than in the Third World. Britain, for example, only has one such in operation at the Human Biology Gallery at the Natural History Museum, and another starting in Bristol, and India only one in Ahmedabad.

But apart from the dilemma of cost involved in this form of popular science, it is necessary to examine the agenda and 'curriculum' of such displays. It is not of course possible to lay out objects either in the old curriculum of glass cases, or in the new inter-active mode without their being a judgement offered about the view of science portrayed. Arguably, it would seem that the new mode will market science more effectively,

\(^5\)Science for People is the BSSRS journal; Science for the People is the American counterpart. Radical Science Journal is a British journal critiquing science, technology and medicine from a radical political, usually marxist, perspective.
but it is possible that the message will be the same at the end of the day. Thus a commentary on the Bristol Exploratory:

It is sad that the educational system does not generate excitement and understanding; and science museums, wonderful though they can be, are passive and often fail to convey the excitement of science. And because they do not understand it, many people reject and fear science. This is why we are setting up Britain's first science centre.46

This message is likely to be that behind the sometimes deceptive exterior, science in all its order and reason awaits discovery. As with some school science kits, the tendency will be to package discovery, particularly in those areas most amenable to uncovering the "mysteries of science". For example in an encouragement to the public to produce a successful exhibit for the Exploratory, the advertisement reads:

All we ask is that your exhibit would invite the visitor to 'interact' with it: it should attract attention but should not reveal all its secrets until the visitor has pressed the appropriate buttons, pulled the necessary levers, or whatever.47

This doesn't mean that science centres cannot play a popularising role, but it is one that needs close analysis. For instance, they could very usefully deal with the area of intuitive belief systems of children (and adults), which we noted in discussing formal science education. Counter-intuitive exhibits and demonstrations could fit very easily into science centres, and could be a dramatic supplement to the work of the schools. But for developing countries, it would at least be worth noting that the large multipurpose science centre is very much (like other superstores) a creation of a particular communications society, where there is no difficulty in transporting busloads of children to a single site. By contrast in China, it has been commonplace for children to disperse into 'many and varied forms of scientific and technological summer and winter camps' where children can participate in observing earth science, astronomy, biology, navigation, solar energy, earthquake zones, etc.48

The main thrust of popular science activities in developing countries seems to be less involved with either the highly

47'The Bristol Exploratory, op.cit., p. 489, emphasis added.
48Sun Ruohan, 'Extra-curricular science education system for middle and primary school students in China', Regional meeting on 'Science for All', Bangkok, September 20-26, 1983.
academic science pressure group of the West, or the work of nonformal science centres. Rather it consists of various modes of participation between science activists and villagers. The range of these interactions are many, and they span the relatively official campaigns of science popularisation (e.g. in Ethiopia), the direct encouragement of each village or larger community to have an urban scientist attached as adviser and trouble-shooter (Korea), or the work of hundreds of individual catalysts working with villagers in India. At the most official level, there is often a sponsored dialogue between villagers and parts of the scientific establishment. The tendency of these official encounters is frankly modernising, or that the artisan skills of the villagers can be improved by injections of scientific expertise. In Korea's scheme for sister relationships between one community and one scientist, the ingredients of success have been: political commitment to the scheme at the highest level; the incentive structure for professors altered to reflect rewards for village-oriented success; and a tendency to attach professors to their own home communities. This institutionalisation of university links to the community appears to have had advantages in both directions:

The people at the grass roots level learned much from having presented their problems to those from the universities, while the university people in their turn obtained invaluable insights into the lessons on how education should prepare people to solve practical problems.  

In Korea, the scientists-to-villages scheme is not an isolated incident but part of a massive, multi-faceted, multi-media attempt to incorporate the rural areas into a science-based society dedicated to relatively high technology, high value-added production, whether in city or countryside. As a small country, with extraordinary levels of political and social commitment to the task of transformation, the issue of alternative frameworks in science and technology, or the role of indigenous knowledge organisation are seen as diversions from the goal of rapid change, and the spread of a modern science and technology climate. With such objectives, the usual tensions associated with appropriate technology versus sophisticated can be resolved in favour of what is needed for competitive production. With rural incomes now virtually identical to urban, the Korean miracle has apparently created a united science and technology climate across the country, and can claim no longer to have the separation of science in cities and poverty in villages that characterises so much of the developing world. There is very little literature available at the moment which examines the social impact of this extremely dramatic penetration of the western science and technology paradigm.

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and on closer inspection it may appear that in the processes of indigenisation and adaptation of technology, there have been important effects coming from older traditions and valuations of science and technology. At this point, however, Korea presents a face that has little in common with the situation in South Asia. The science popularisation is presented as involving all in a unified cause of rapid modernisation, and to this extent it really appears that Korea is a perfect exemplar of the UNESCO slogan 'science for all'. The thrust of the campaigns is uni-directional, and there seems, perhaps understandably, to be little questioning about the science and technology paradigm which Korea has manipulated so signally to her advantage.

This modernising strain is evident in other countries, and manifests itself in slogans like 'scientific temper', in science policy resolutions, and in many other programmes and projects, but it is immediately obvious from the context of such statements that science has not got the field to itself. Over against scientific temper are ranged the forces of tradition, superstition, communalism and parochialism according to the many debates on this theme. In one of the more recent of these set pieces in India, a group of distinguished scientists have each spoken out on the theme of 'scientific temper or bondage of traditions', and contrasted the rationality of the scientific method with the tendency to be governed by unreason and obscurantism. The tone of these arguments makes it clear that the scientific temper is conceived of as a political philosophy, whose absence accounts for the ills of the state. By contrast, the Green Revolution is an excellent example of the scientific method in action; science, knowing no frontiers and respecting no particularistic criteria, proceeds to benefit the nation:

Notice that the method used in the above situation (green revolution) concerns itself only with the conditions of seeds, soil, water and so on, and not with whether the seed belongs to a Hindu or a Muslim, or whether the field is Indian or Burmese. These are irrelevant to the problem; what is relevant is the actual seed and the soil, the quality and amount of water and physical environment, and not the nationality, religion or political policy of the individual or the country.

... Geographic parameters such as soil hardness, rocky terrain, or weather conditions are considered but not the religious beliefs of the farmer or his family life - these make no difference to the problem on hand or its solution.50

This classic statement is reminiscent of the International Rice Research Institute with its belief in research knowing no frontiers, but it typifies the view of science as an entire system and method, itself uncontaminated by social and political forces, but hopefully becoming the ruling principle. At the moment the ills derive allegedly from the separation of science from the state, but if the scientific method can overtake the state itself, all will apparently be well:

We have mentioned earlier that the method of science be made use of in all aspects of human endeavour from ethics to politics and economics. Much of the impediments in societal or national progress stem from a refusal to adopt scientific temper or from confining the scientific method to problems of technology or health alone and not to all problems associated with human progress.51

The perception of science not only as a method, but as a systematic and culture-free approach to politics, contradicts much that has been said above about the origins and paradigms of western science and technology. Still in one form or other, the gospel of science as the moderniser and shaker of tradition remains strongly held, and is the activating principle at work in many of the science popularisation movements. Several of these assume that what villagers require is a large transfusion of scientific temper, to alter their fatalism, their prejudices, and their traditional belief systems. In this kind of people's science project, therefore, it is the scientist who is carrying science to the people, in the hope that the new gospel will not only have cognitive consequences, but more importantly alter the attitudes and values of villagers. In this respect, science though contrasted with the evils of religion and dogma is recommended for its impact on values. So far there has been little detailed research on the nature of the science and the associated values carried to the villages by many of these dedicated scientists. However, Krishna Kumar has drawn some important threads linking the assumptions of the scientific temper activists with those common to western analysts of underdeveloped societies in the immediate post-independence period:

Many writings of the period used an evolutionary paradigm ... to explain a "missing factor" in the societies of the poor countries. The missing factor was identified by many commentators in terms of cultural or behavioural deficiencies; as a lack of certain traits that were regarded as necessary for rapid economic growth and social change. These were traits such as achievement motivation, initiative, independent will, and affective neutrality. The

51D. Balasubramaniam, op.cit.
socio-political programme of science educators resembles the early developmentalists in as much as it links certain observed traits in the behaviour of poor people with their political 'subservience. The diagnosis offered is similar, only the symptoms are named differently.  

There are several variations of this approach. Some involve bringing to bear on artisan technologies in the village the insights of the national system of scientific laboratories, as for example in the current scheme for 'village artisans and science' of India's Council of Scientific and Industrial Research. Others may have less institutional backing, but they conceive of nonformal science education being an engine for rural development. One interesting aspect of these programmes is their strong emphasis on science, despite the evidence that much of what is on offer is technology. It seems almost as if science is used as a symbol, for the 'curriculum' of science education in some programmes is so practical that it appears to be at the very end of the spectrum from school science. Much more work needs to be done on the nature of this 'science' for villages, but a not untypical account comes from the Vidyan Ashram, near Pune:

The methods and approaches of science cannot be inculcated except by practice, which in turn is possible if one sees it as effective. The methods we try to inculcate relate to 1. discerning patterns; 2. cause and effect relationships; 3. quantification and measurement; 4. experimentation; 5. recording and exchange of information. These should be imparted by games, exercises and use. The most creative mind will not be effective unless it has information to work on. As the time is very short, it is possible to absorb only a limited stock of information and we would like to give only that which is relevant to local life. Instead of trying to write down a syllabus for this, we decided to start tackling the local problems and give only information which relates to them. Over a period certain concepts and fact get repeated and will be absorbed.  

These encounters between the formally-trained scientist and artisans, or other villagers, have been little documented, but there are important questions to be asked about what happens to the scientist's science when it is deployed in a village setting,

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52 Krishna Kumar, 'Science Education and Development', Centre for the study of developing societies, mimeo, New Delhi 1983, p. 14.


or to the science of the National Metallurgical Laboratory when it confronts the improvement of rural artefacts. It is possible that the dialogue could be a very fruitful illustration of interaction between two very distinct traditions — the world of the craft worker and that of the government scientist. One of the few detailed examples of how this interaction between different paradigms cannot remain a merely technical question of urban science improving rural technology is contained in a qualitative account of the Jawaja weavers and leather workers who became involved in the ‘rural university’ outreach organised by the late Ravi Matthai:

For anyone thinking that improving the design of the weavers and leather workers, and arranging small bank loans is something that can be rapidly initiated, and can allow the project team to move on elsewhere, these (Jawaja) letters are compulsory reading. There turn out to be almost endless ripples of obligation and accountability that spread out from the few initial changes in design and in tanning technology; there is also a constant awareness of the trade-offs between fixing things and increased dependency.55

Not the least significant of these various initiatives taking scientists to villages is so obvious it is seldom remarked on: the presence of highly trained post graduate personnel in a village is so unusual, it may be expected to have an effect almost independent of the science and technology message that is being imparted. Unlike traditional agricultural extension systems — where the village workers are at the bottom of the agricultural research hierarchy, and are the last link in a very attenuated chain, the scientist settling in a village for a long time could have a powerful impact as a ‘science missionary’.

In the rather different context of Colombia, when FUNDAEC was rethinking the whole traditional chain of knowledge generation from research centre to the peasant, it had also become clear that by privileging the village-end of this process, one would be challenging the view of the village as the passive consumer of predigested technology packages:

While this institution (FUNDAEC) would not be involved in activities such as the development of new varieties, its tasks would be far more complex than that of an extension system including feedback mechanisms, and it would need to have much more scientific capacity than has traditionally been allotted to institutions working at the grass roots level.56

55 K. King, 'Science, technology and education research in India', op.cit., p. 15.
56 F. Arbab et al., 'Fundaec: an experience in rural development', mimeo 1983, p. 45.
Science Activism and Grassroots Movements

Conceptually distinct from science as modernisation, but sometimes appearing in the same movement is a form of science-as-liberation. In many cases, however, this liberatory science is on the agenda of what have come to be called non-party political formations, that is, in the myriad of small local grassroots initiatives working with marginal groups. Such grassroots movements are independent of the traditional party processes, and are also separate from the more establishment non-governmental organisations. Their work is almost exclusively with the large sections of the population who have profited little from three decades of independence and 'development'. In recent months, the crucial political and social character of these small groups has been analysed by Harsh Sethi, D.L. Sheth, Ranji Kothari and several others, and there is the beginnings of a small literature laying out the nature of this 'new politics' in the rural areas.  

By no means all of these grassroots movements would identify themselves with some form of science-for-liberation, but there are a number of characteristics of their approach to knowledge and its utilisation which strike chords with some of the alternative paradigms to which we have alluded. It is in fact premature to be more than tentative about the meaning of science in the titles of some of these movements, or to assess the use of scientific expertise by them, for the very good reason that few descriptions exist except in outline form. Although it will be important to know more about these science and action agendas, it is well to heed the warning of Sheth about the use of evaluation research and its assumptions in documenting such initiatives. 'Scientific' evaluation criteria could easily 'delegitimise' the popular science purposes of these movements:

This is done in the name of 'evaluation' studies of these new experiments and organisations, mounted by established social scientists, both foreign and local. In this, the work and role of grass-roots movements is assessed not in terms intrinsic to their existence, but against the establishment criteria of what development is and what it is not.  

Even though data is scanty, there are a few pointers to the nature of this science activism. First, in India, the nature of these grass-roots organisations has been much affected by the

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58 Sheth, op.cit., p. 259.
movement of middle class, educated youth to settle and work with the marginal groups, whether tribals, agricultural labourers, backward castes, etc. To this extent, there is therefore a similarity to the various modernising science groups, since both contain as catalysts highly educated, committed urban dwellers, often with a science background. The difference with the grassroots groups is that on the whole they are searching for an alternative model of development to that which has allowed the tens of millions of rural dwellers to remain in poverty, whereas the modernising groups may see the problem as partly an absence of that very development mentality. It is possible however that there may be a continuing tension between the science paradigm in which the catalysts or change agents were educated and the demands that knowledge empower the poor. It implies a complete change in the aspect of science from its association with selection, elite formation, and traditional R & D models, to one where it is expected to be raising the awareness of the poor, and demonstrating alternative methods for maintaining health, technology and the environment. In this, it may often in Sethi's words be converting 'an ostensibly "neutral technical profession and task" into a "political" one'.

A second aspect of this science activism is its tendency to pay attention to indigenous technical knowledge over against the scientific development schemes which have in many instances threatened the balance and stability of older ecological systems. In many other countries modern science (whether in forestry, agriculture or fisheries) has paid much more attention to the commercially exploitable, export crop than to the ordinary food crops and local uses of timber. Consequently, there is considerable scope for research on subsystems that mainstream science has neglected, and in pursuit of these, there is advantage in making the research itself participatory; so that the very people whose habitat is threatened by commercial interests or monocrop farming can become conscious and articulate about their local resources. Examples of such scientific awareness creation can be noticed in the Kerala People's Science Movement (KSSP) in relation to the Silent Valley Scheme, or the Chipko Movement in the Himalayan forests. While one of the most useful statements about the participatory methodology applied to science and technology is Shiva and Bandyopadhyya's, 'Participatory research and technology assessment by the people'. To some extent, it may appear that such participatory science research is defensive and reactive to crises created from time to time by the intervention of commercial interests or 'development' plans. It might be argued that an alternative science and development strategy may be difficult to construct around the irregular incursion from such quarters, and even more, if alternative frameworks are to take local knowledge as their starting point,

the specificity and uneven distribution of such knowledge may be as marked in its own way as the specialisation and elite character of the dominant science paradigm. Conscious perhaps of this dilemma, science activists see the participatory mode as a two way process - in which neglected knowledge begins to feed into the national awareness, and in which the role and character of the dominant science system is translated into the people's local perceptions. However, one of the most critical aspects of this translation is that the broker between the two systems is the science activist or catalyst. In a small local initiative an enormous burden and responsibility must fall on this translator, as Shiva and Banyopadhyya admit:

In this sense, elite knowledge must be recognised as a source of power and exploitation - and countering this knowledge by knowledge generated through participatory research becomes a very essential and potent aspect of people's struggles. If this process is to materialise, the macro-researchers have to identify themselves with the people and play the double role of subsuming people's knowledge into professional terminology and re- translating macro-knowledge into popular language.\(^6^0\)

One further point should be made about this brokerage role. It would be important to know more about the scientific perspective which the broker brings to the study of local knowledge systems, and in turn to the selection and translation from the dominant knowledge modes. Is the expertise with which they counter the intrusive technologies and with which they analyse the local technical knowledge based on that same Western scientific method? Once having accepted that the western science and technology system is not value free, generalisable and epistemologically superior, is there still a legacy of procedures and approaches which science activist derive from western science? The question is important for it relates to one that Farzam Arbab has raised: whether the essential text of western science is good, and only the claims made of it and its applications by particular interest groups appear to make it bad, or whether the text of science itself is at fault.\(^6^1\) Perhaps only more detailed studies of science-in-action in these campaigns and in these interactions can answer these questions. But in rejecting the reigning economic development model, with its exploitation of resources needed for popular livelihood, is there a role for scientific expertise to counter the case made by the 'developers'? If this is so, is there then a set of tools that science (or social science) makes available, whether in participatory research or in the older R, D and D models? Is there a minimum western science package or 'kit' which can be utilised for expertise, regardless

\(^6^0\)Shiva and Bandyopadhyya, op.cit., p. 123. Emphasis added.

\(^6^1\)F. Arbab, comment during ESPRA seminar, New Delhi.
regardless of political perspective?\textsuperscript{62}

Although it is plain that the reinterpretation of indigenous knowledge in science, agriculture, education, and medicine can provide a starting point for the alternative approaches to science which we have discussed, it is important to acknowledge that in some parts of the Third World researchers feel this local option does not exist, as an aid to developing different frameworks. According to Farzam Arbab for example, there is in Colombia no viable alternative that can be nurtured in the field of agriculture. Consequently there is a pointlessness about those 'who reject modern technology and try to seek solutions in the traditions of each rural region. In general, they tend to romanticise the past and try fruitlessly to recuperate it'.\textsuperscript{63} From a rather different perspective it is worth noting that the largest of India's popular science movements, the KSSP, which has fought a number of developmental projects, is anxious not to be identified with a zero-change approach to the environment: 'Great care had to be taken to dispel any possible impression that the stand amounted to an anti-development view. It was with this in mind that feasible alternatives which would confer greater benefits to the people in terms of employment and income were worked out and propagated'.\textsuperscript{64}

In several quarters it can be seen that there is an anxiety to distinguish the reinterpretation of local knowledge systems from an anti-science kind of revivalism. Popular science movements have therefore to tread a very narrow path, critiquing the excesses of modern science and technology, equally with contesting the view that the modern is alien. Among the several conflicting versions of 'science popularisation', the middle way may frequently have the least appeal politically or emotionally. Thus, science popularisation that simply wishes to spread broadcast the values of western science and technology is undoubtedly easy to understand, and, like a literacy campaign, can be mounted readily, given political commitment. Similarly, a campaign against the infiltration of western influence in science and technology can easily gain political support. Compared with these, a science popularisation that reinterprets and rediscovers the changing local traditions while sorting and selecting from other technology traditions is conceptually difficult to grasp. In addition it has to forge a methodology for this double sorting that goes beyond the rhetoric of participation,

\textsuperscript{62}Dinesh Mohan has commented on the value of the set of science tools, even for those countering the incursions of western science, ESPRA seminar, New Delhi; for a further example of countering the expertise of the dominant development models, see J. Bandyopadhyay and V. Shiva, 'Planning for Underdevelopment: the case of Doon Valley', Economic and Political Weekly, vol. 19, no. 4, January 28, 1984.

\textsuperscript{63}Arbab et al., op.cit., p. 41.

\textsuperscript{64}Science for Social Revolution, KSSP, Trivandrum 1980, pp. 22-23.
and identify areas of analysis far beyond the domains of the still uncolonised Masai herdsmen, the tribal peoples and the forest dweller.\textsuperscript{65}

One of the most difficult tasks in this search for a legitimate or appropriate popular science is changing the discourse away from saying what it is not, towards descriptions of what it is. Currently there are scarcely any detailed descriptions of what is involved in bringing an appropriate science and technology to light. There is, however, no shortage of general statements and declarations in favour of 'Another Development' or of the need for 'endogenous development', but these need to be translated into detailed drawings, if they are to move from the agendas of international meetings to reflect the problematic search for alternative frameworks.\textsuperscript{66}

One of the few such detailed drawings is contained in the ten years' search by FUNDAEC, the 'rural university' in Colombia, for an appropriate model for the development of human resources and of technology. The account of the development of theory and the challenge of practice, the successes, the cul-de-sacs, the failures are all essential if there is going to be built up in different settings a new paradigm or an alternative framework. Part of the singularity of FUNDAEC was its insistence on developing human resources and technology in tandem, not assuming that either had to become sophisticated through the conventional structures for acquiring academic status and academic complexity. Educational and technological appropriateness had to be understood in terms of a dynamic relationship to each other, rather than to any traditional stages of development:

The appropriateness of technology is a changing quality that would have to be understood within the broader context of the process of development with the human being as its primary concern. The needs, the aspirations, resources, and capabilities of a population at a given moment are clearly important factors in determining the worth of a technology, but they have to be examined in light of their contributions to the expansion of the scientific and technological capacities of the population. A simple technology may be quite inappropriate if it leads to stagnation, and a complex one may be appropriate or not, depending on the

\textsuperscript{65}The complexity of finding a legitimate people's science and technology is well illustrated in a recent dialogue between the Patriotic and People-oriented Science and Technology (PPST) in Madras and local writers: see Lokayan Bulletin no. 8, pp. 3-10 '... some members of the PPST suggested that the writers should help the intellectuals by identifying practices of traditional science and technology in obscure corners of the country' (emphasis added).

\textsuperscript{66}One of the better known attempts to stake out the high ground for alternatives is Another Development: Approaches and Strategies, Dag Hammarskjold, Uppsala 1977.
accompanying educational process and whether it leads
to real understanding of and complete control over
the technology. The rural university was thus
beginning to understand appropriateness more and more
in the context of the systematic learning process
within the population about its own path of develop-
ment, in terms of which it was already formulating
its concepts of education.⁶⁷

In the light of this insistence upon a coordinated development of
human resources and of science and technology, it is interesting
to note that similar kinds of actions groups see themselves
concerned with 'popular education' in Latin America and 'popular
science' in India. It is almost as if education and science are
seen as platforms for the new politics of these many groupings,
but they are not the old conceptions of science, technology and
education. The reformulated relations between science,
technology, education and politics are embryonic, but the example
of FUNDAEC and of several other action experiments suggests that
a new social relations of science is feasible. There does now
exist a solid body of work on alternative technologies; there is
also considerable work now available on alternative, participatory
research techniques, and these will prove very relevant for
further detailed case study work on popular education and science
movements. It should therefore be possible to move from the
present situation of an array of scattered movements to a new
conceptualisation.⁶⁸

But the task of privileging this alternative image should not
be underestimated. Despite all the criticism the dominant
science and technology paradigm is still in the saddle. The
international agricultural research centres continue to exemplify
the approved system for developing and distributing new agricultural
information. International science congresses continue to
operate on the assumption that there has been no basic criticism
of the mode of western science and technology, or that criticism
from the Third World can be met by encouraging the export of some
portion of the same research technology to the developing world.
Over against all that has been said in this paper, national
governments proceed with plans for investment in the same paradigm,
whether in new information technology, elite science schools,
science cities or other manifestations of the belief that science
can develop or transform society. This is of course not just a
science phenomenon, but part of a wider problem of transnational
knowledge production and power, and their impact on developing

⁶⁷F. Arbab, et al., Fundaec: an experience in rural development,
op.cit., p. 42.

⁶⁸See also UNRISD, Popular Participation Programme, 'Social
countries. The empowering of alternatives in the Third World is therefore inseparable from the analysis of the 'world system' to which Arbab referred at the beginning of this paper, nor can it fail to take account of the vitality of the dominant paradigm and its set of supporting structures which Weiler has mapped out:

Much of this (Third World) criticism is, of course, directed against trends towards the monopolisation of knowledge production, especially in social research, by a single paradigm or "symbolic universe" - a monopoly which reflects the overpowering role of the North American research establishment and the paradigmatic traditions which ... have come to dominate that establishment over the past fifty years ...

Beneath this overt criticism of a reigning paradigm, however, lies the recognition of a much more fundamental dilemma: the recognition that what is really at issue is not "just" the world of knowledge production and research, but a much more intricate web of relationships in which the production of knowledge is one of several interlocking elements for the consolidation and legitimisation of the existing institutional order at the international and transnational level. The transnational system of knowledge production is inextricably linked to a transnational system of power, in which publishing interests, research funding, consulting firms, testing services, professional associations and development assistance agencies all form part of a powerful - if less than perfectly co-ordinated - centre. On the other side is the research community in a weak and, above all, fragmented periphery which finds itself not only dependent upon many of the centre's resources, but also locked into an intellectual agenda which is jointly sanctioned by the dependent state and the economic and political forces in the centre of the international system ....

One conclusion from situating the search for alternatives within an awareness of these wider international constraints is to make sure that the analysis of a new politics of science, technology, and education does not get located solely in the periphery of the periphery - seen as an appropriate defence strategy for the poorest of the world's poor, but not being particularly relevant to mainstream national and international knowledge systems. Researching alternatives must also relate directly to the role of science and technology in the so-called modern sector, or organised sector of the economy. Hence there is a need in parallel with the development of theory among popular movements to investigate alternative conceptions and

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69 H. Weiler, 'Knowledge and legitimation: the national and international politics of educational research', Comparative and International Education Society meeting, Atlanta, March 18, 1983, p. 21.
meanings for scientific and technological manpower. Here too, despite all the criticism of traditional paradigms in manpower planning, with their emphasis on middle and higher level technical and vocational training, these human capital models continue to dominate, and are being fast updated and adapted.\textsuperscript{70}

By contrast, alternative models for examining the role of scientific and technological manpower are scarcely available, and where they do exist, they have seldom the visibility or impact of manpower analysis coming from the traditional sources of expertise in the ILO, or the World Bank. A sustained critique of the conventional wisdom on skills development cannot be found, but must at the best be pieced together from commentaries scattered here and there in the 'grey' literature.\textsuperscript{71}

What are the implications of this situation for the many scattered researchers working on the new politics of science, technology, skill, and education? Is there a way of achieving greater salience for the approaches with which this paper has been involved? Currently, such alternatives little affect national and international planners in science and technology, manpower economists or even the hundreds of thousands of science educators. Are there ways that the body of alternative thinking and acting on these issues can be brought in from the periphery and can begin to affect science and technology policy at the central level? The following are a few suggestions that may point in the direction of a research and dissemination strategy for these alternatives:

1. Much more case study material needs to be made available documenting the insights and strategies associated with these new approaches to science, technology and education. While resistance and suspicion of conventional evaluation techniques is commonplace amongst groups attempting new initiatives, appropriate forms of participatory evaluation are now available, and in the absence of published accounts of alternative theory and practice, the field is left to the traditionally dominant paradigm.

\textsuperscript{70}See for example the papers in the South Asia Regional Conference on Skilled Manpower Development, (Government of Sri Lanka and World Bank), Sri Lanka, January 1984, mimeo.

2. Building theory from the many micro-initiatives in Asia, Africa and Latin America is a priority task, not principally to understand new forms of participation and politicisation amongst the poor, but to see one of the major sources of criticism of the current 'development' theories.

3. To counter the universal 'culture-free' science of the schools, universities, and science congresses, many more accounts of culture-dependent science and technology are needed - fully developed sciences yet ones that will bear the marks of India or China's rich and complex scientific past and present.

4. Although very few funding agencies are prepared to support research and dissemination of alternative knowledge frameworks, those that are inclined (UNRISD, IDRC, SAREC, UNU, IIEP, CLACSO, for example) should be requested to make possible a great deal more South-South learning, as well as exposure to alternative foci on science and technology in the North. In addition, given the impact of Northern scientific and technological research on the South, it will be important to encourage Southern research on the latest technological changes in the North.

5. One of the most essential routes to strengthening alternative paradigms is to produce materials suitable for teaching, in graduate schools of education, development studies, and science and technology policy. New materials are also urgently required for the school system itself.

6. At the moment, the conventional paradigms predominate in all the key planning sections of ministries of Education, Manpower, Science and Technology, Rural Development, Agriculture and Industry. Ways should perhaps be explored of exposing policy research personnel in these ministries to alternative conceptions of skill, science and technology, agricultural extension etc through workshops and high level seminars. In the absence of some such initiative, policy makers continue only to have access to workshops on project evaluation and monitoring, manpower analysis, technology assessment or on investment in science and technology education, most of which will take no account of the concerns expressed in these pages.

The search for an integrated alternative vision will proceed, and will be conducted not only in the defence of the very few unexploited peripheries (such as the Amazonian rain forest), but more centrally in the ordinary village schools and training centres, amongst science teachers, and in science and technology policy centres. But the search cannot preclude attention to those parts of the Third World pursuing the popularisation of the traditional western science paradigm, whether in South Korea, Singapore or elsewhere. Countries that have aimed at
transformation by investment in science must be part of the agenda of research, and not only the myriad of scattered initiatives that have some sense, that a 'post-modern science' may be emerging from the discrediting of the current paradigm.\textsuperscript{72}

It is too early to say what a new linking of science and values (a 'technoethic' in Nandy's words) will look like in different countries but it will need to incorporate not only the traditional and changing technologies of the countryside but the current industrial and evolving information technologies of the city. One version of that vision is J.P.S. Uberoi from his book \textit{Science and Culture}; who sees that the alternative framework is fundamentally about the reorganisation of knowledge production:

On the scientific side, the new way of life and thought will require us to restructure the project, the curriculum and the hierarchy of the special sciences, theoretical and experimental, so as to discover and affirm the higher unity of the subject and the object, the man and the system. The new classification will abjure within every special science the distantiation of outer nature from the inner man, the participant from the observer, as a principle of knowledge. For example, within the new physics, a search for the elementary structures of mind as well as matter should replace the search for the elementary particles of matter as its object. This will in its turn point some new relations between physics and psychology and between physics and ethics as well as between physics and mathematics. The new social sciences will learn to live and let live within the new vision of the whole. Similarly, medical science will have to add inherently the concept of sanity (subjective) to its concept of health (objective), defining human life as health plus sanity inseparably from the start.

I am persuaded that so long as the problem of the alternative is seen in India and elsewhere in purely practical extrinsic terms, whether political, social or economic, modern Western science itself will remain a stranger and liable to exploit us for its own ends. Its so called diffusion, implantation or assimilation in the non-Western world will very properly remain a failure or turn into something worse. On the other hand, if the intrinsic intellectual problem of the positivist theory and praxis of science and its claims come to be appreciated by us, leading to a dialogue with native theory and praxis, whether classical or vernacular, then modern Western science will find itself reconstituted into something new in the process. Let us see whether the king

\textsuperscript{72}Ashis Nandy, comments at ESPRA seminar, New Delhi 1984.
who makes all the laws of modernity cannot be brought himself within the semiological law, i.e. in relation to the project, the curriculum and the method of science. 73

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RECENT TRENDS AND ISSUES IN SCIENCE

EDUCATION IN SOUTHEAST ASIA

Dean Nielsen
In Southeast Asia, learning in science, more than in any other subject, is considered to be a prerequisite for modernization and national development. Thus, over the past two decades, which have been characterized by movements towards industrialization and accelerated economic development, science education has been at the fore of curriculum reform movements.

During the early years the reforms in science education emphasized science for the development of scientific and technical manpower, since there were (and still are in many places) acute shortages of trained manpower in these fields. Rigorous scientific training was emphasized during those years, mirroring reforms in the West during the post-sputnik era, stressing knowledge in the traditional scientific disciplines and an academic approach to learning.

During more recent years, science education in Southeast Asia, once again following cues coming out of the West, has become much more process or discovery oriented, but, in addition, has begun to lay much more importance on relevance to local needs and conditions as well as egalitarian issues, epitomized by UNESCO's 'science for all' movement.1 Under these influences, science educators in this part of the world have begun to present science as a promoter of logical thinking and a developer of problem solving skills, not only among the scientific elite involved with complex problems and high technology but also among the average wage earner and home-maker in their day to day struggles to make a living and provide for their families.

The current review examines some of the trends related to the general situation described briefly above. It will focus chiefly on primary and secondary education, using material gleaned either from written documents or informal interviews. This paper does not present an historical account of reform movements in science education in Southeast Asia and it is not intended to be comprehensive. Instead it is intended to cover, in a somewhat impressionistic manner, trends in six of the most frequently discussed areas of science education, namely:

1UNESCO Regional Office for Education in Asia and the Pacific, Annotated Agenda for Regional Meeting on 'Science for All', Bangkok, 20-26 September 1983.
Curriculum reform
School science equipment
Teacher training and retraining
Nonformal science education
Research in science education
Regional collaboration.

In certain of these areas some countries will be featured and others not. This is not necessarily because those countries are particularly representative of the area. It is because their programs are especially interesting or innovative or well known. Inevitably certain of the most interesting innovations will be overlooked simply because I, as a layman in this field, simply did not have access to the appropriate information.

1. Curriculum Reform

a. Integration. Critics of science education during the 60s and 70s found it to be dull, overly academic and fragmented. It was one of the most unpopular subjects among students, partly because of the way it was presented and because it generally had very little to do with their everyday experiences. The integrated science movement, strongly supported by organizations like UNESCO, was developed to make science more problem and society oriented, and thus, presumably more interesting and less intimidating to children. Two kinds of integration were advocated, that among sciences (to counteract fragmentation) and that between science and social studies (to promote social relevance).

Examples of this abound in Southeast Asia.\(^2\) In Malaysia, for example, a phased primary school curriculum reform introduced in 1982 will present to pupils in primary 4 a new course entitled 'Man and his environment', an integration of various sciences and social studies. The main purpose of that course is to establish an appreciation of science in the modern world, a goal consistent with a recent regional UNESCO conference call for science education which above all would establish and maintain a positive attitude towards science and technology. Malaysia also offers an integrated lower secondary school science course, which is social problem oriented, emphasizing themes like environmental pollution, energy conservation and consumerism.

In Thailand, the Royal Thai government's Institute for the Promotion of Science and Technology (IPST) has developed an integrated science approach for elementary schools which combines

health education with science and social studies.⁳ For the lower secondary schools IPST has developed an integrated science curriculum which emphasized the triangular relationships among ENERGY, CHANGES IN MATTER, and the ENVIRONMENT.

b. Relevance. Advocates of indigenous curriculum reform have insisted that science must be presented in such a way that it is relevant to a country's needs and resources. The position has also been advanced that for science to be attractive and meaningful to most children it must impinge on their daily life experiences and be geared to their level of cognitive development. Besides those who call for relevance to national problems and context, there are those within nations who call for adaptations to local environments and conditions, particularly in nations like Indonesia and the Philippines, where there is wide regional variation.

Examples of this movement are perhaps most plentiful in the Philippines, where the official national curriculum states that science education must be connected to the needs of the country and development goals. The prestigious Science Education Center at the University of the Philippines (UPSEC) has conducted numerous community surveys and made profiles of students and teachers in an effort to develop science learning modules with materials relevant to local problems, needs and resources to supplement national textbooks. Perhaps the best single example of this is a joint UPSEC/UNICEF project called 'survival of the family', which started with a community needs assessment and ended with villagers experimenting with different types of traditional medicine and ways of salting fish.⁴

In Thailand, relevance to national problems and conditions is stressed in every part of the new national curriculum, but perhaps the best examples come from the upper secondary courses, those developed for the science stream students. For example, the course in biology is centered on the examination of the biology in the immediate environment of the learners. Moreover, the chemistry course at the same level puts special emphasis on the chemical industry of Thailand.

c. Process skills. All of the countries in the region are engaged in a movement to make science education more process skills oriented than it formerly was. More part of an international Zeitgeist than a result of indigenous pressures, and perhaps originating with the Nuffield science curriculum and/or


the Scottish Secondary Science course, this movement stresses a move away from a fixation on scientific knowledge towards an emphasis on inquiry skills and discovery learning. Such a focus, accomplished generally through active learning approaches (doing experiments, going on field trips, observing natural phenomena, discussing problems), is expected to produce in students greater capacities for logical or hypothetical thinking, for data gathering and interpreting, and for problem solving.

Indonesian science education developers have invested heavily in the process skills development movement. A primary science project in West Java, being developed by the Indonesian Office of Educational Research and Development (Balitbang Dikbud) with help from the British Council, has made process skills development its main objective. This it pursues by focussing on a limited number of scientific concepts which are presented through learner-centered activities, using simple equipment. This system, which is being developed as a prototype for national use, relies on intensive retraining programs using the school supervisor as a trainer. A secondary science program with a similar focus has already been disseminated nation-wide. Although students at this level are still constrained to cover a discipline-oriented, overly dense curriculum, their learning activities are structured through the use of a series of worksheets, supplements to the textbooks, which call upon them to perform simple tasks and experiments.5

In Thailand the inquiry approach to science learning permeates the new IPST curricula. Intended to promote critical thinking and problem solving skills, the new student books place students in the role of discoverer. This is true for science courses geared not only for those who are bound for higher education, but also for those in vocational tracks. For example, in the vocationally oriented upper secondary courses, special science courses have been created by IPST which stress science process skills geared towards problem solving on the job and towards situations in everyday life.

d. Value orientation. A recent phenomenon, related to the emphasis on linking science study to social problems is the concern for 'value-oriented' science. This trend, articulated recently by science educators at a regional meeting at the SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM), results from a concern for the abuses that sometimes accompany scientific and technological development.6 The meeting held during June of 1983 heard RECSAM officers calling for science for a more humane and caring society and the promotion of global harmony. It also heard Singaporean educators call for 'humane

5Euwe (Ed) van den Berg, 'Science Education in Indonesia', Satya Wacana Christian University, 1983.
6RECSAM, Final Report, op.cit.
rationality' and a Malaysian University Vice-Chancellor call for more humility among scientists and more awe in approaching the wonders of God's universe. The conference ended by calling for a science education more related to the ethical concerns of man, placing greater emphasis on the social accountability of scientists and technologists and scientific discipline. It also highlighted a need for science to address the issues of drug abuse, energy conservation, consumerism and environmental pollution.

2. School Science Equipment

The active learning models stressed by all of the countries in Southeast Asia require students to work on tasks and make observations of scientific phenomena. This requires laboratory equipment, something extremely scarce in most of the countries in the region because of cost and distribution factors. To make up for this equipment deficit, there have been basically three approaches in the region. Manufactured equipment has been imported from the developed nations, curriculum development centers have fashioned their own equipment using local, low cost materials, and teachers have been encouraged to create their own equipment from locally available materials.

Singapore has embarked on a campaign to equip all of its secondary schools with well equipped laboratories, often using imported materials, at considerable cost. It is estimated that one such lab costs the government around US $ 350,000, not an uncontroversial sum of money. In Thailand science equipment has been developed and tested by IPST as an integral part of its science curriculum development. For some levels the science equipment has been mass produced with help from the private sector producers. At others, prototypes have been centrally developed and then sent out where they are produced in greater numbers locally. In Indonesia the process oriented science programs have relied on the production of simple equipment by the teachers themselves, sometimes with aid from a regional science center. In addition, there has been at the national R & D Center a project for the development of a simple, compact science kit. This kit, developed with help from the German government and due to be distributed to 100,000 schools, is considered to be quite ingenious, but since it is not directly related to the teachers, there are doubts about whether it will be used effectively.

The successes with equipment and development and use in Thailand seem to indicate that such equipment needs to be designed and tested in conjunction with actual science lessons.

The Thai experience also seems to show that mass production, involving a commercial producer working with the ministry and the curriculum development center, leads to the best materials at the lowest unit costs. Materials can be (and were in Thailand) produced at lower initial costs out of very cheap local materials, but such materials do not last very long. This has also been the case with materials made by teachers themselves. In fact, even the sturdiest of manufactured equipment sometimes needs to be repaired, a fact reported by Thai teachers. Thailand has thus been experimenting with offering training in equipment repair at regional science servicing centers.

3. Teacher Training Support

All of the innovations mentioned above can be a source of bewilderment to the teacher in the field, especially considering that even in relatively wealthy Singapore very few of the practising science teachers were actually trained in science in the first place. Thus most countries in the region have designed inservice teacher training courses to provide science teachers with special support. In addition, some countries have established teacher science centers serving a cluster of schools, others have produced elaborate training packages and still others have begun to provide special bulletins. Besides innovations in in-service training, there have also been some interesting efforts to upgrade and update pre-service training at teacher training institutions.

Indonesia provides some good examples of innovative in-service teacher training for science teachers. In their secondary science program they have instituted an 'inservice-onservice' approach, which consists of cycles in which teachers come to the center to learn new approaches and prepare new lessons, return to their classrooms where they apply their new skills under observation, and then come back to the center again for feedback and a new round of lessons. This program also provides a local science center where teachers from a cluster of schools can receive guidance and reinforcement. Indonesia's primary school program uses a similar approach, but in the former the trainers are experienced teachers (who have been through a course at RECSAM and a study tour) and in the latter the trainers are primary school supervisors. Indonesia has also used weekly educational radio broadcasts for in-service training, but not within the context of the two new science programs.

In Thailand IPST has supervised the retraining of over 25,000 secondary school teachers, based on the reformed curriculum. Since primary school teachers are so numerous and the costs of

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retraining them judged to be prohibitively expensive, IPST has developed special primary science teaching-learning kits. These kits contained a detailed teacher's guide and supporting materials, but it is not certain whether or not teachers are able to follow them with sufficient effectiveness. New plans are now being laid to provide additional support through school cluster centers or science teacher servicing centers.

Singapore has developed a unique form of support for teachers. It is called Research and Evaluation Abstracts for Classroom Teachers (REACT), which is precisely a set of research abstracts sent to teachers twice a year covering various subjects (the most recent edition, December 1983, covered studies in science teaching and learning and studies in the education of slow learners). At the end of each abstract there is a section which suggests ways in which the findings could be applied in the teacher's own classroom.

Finally, both the Philippines and Thailand have been developing new approaches to pre-service teacher training. In both cases the courses have been based on the competencies required for the delivery of the new curricula. Studies have been conducted in both places to determine what existing levels of competency are, and then the courses are structured to deal with the discrepancy between ideal and actual levels.

4. Nonformal Education

A heightened concern for social issues among science educators in Southeast Asia has prompted them to consider the need and right of people of all walks of life to obtain the tools and benefits of modern science. The UNESCO 'science for all' movement (to be described in more detail below), recently convened a seminar in Bangkok to discuss, among other things, mechanisms for promoting scientific literacy and popularizing scientific attitudes and concepts. The suggestions included a number of varieties of nonformal education, many of which are already being used within the region.

For example, in Thailand the country's Science Society has promoted a number of science clubs, science fairs, science awards and a National Science Day. In addition, Bangkok has established a science museum that is so popular that mobile versions have been added to reach enthusiasts in rural areas.

Singapore also possess a popular science center, which uses a number of interactive and operatable displays. In addition, it has in recent years established computer clubs in high schools and community centers, which have grown more and more popular with the availability of relatively cheap, locally assembled microcomputers and pirated software.

One of Malaysia's approaches to the popularization of science is the establishment of an off-campus study program at its science university (Universiti Sains Malaysia). This program was originally set up to provide part-time, degree oriented study programs as a 'second chance' for those already in the work force. In addition, it was supposed to narrow the gap in science learning among ethnic groups, by providing a special 'science foundation course' (a degree program with modified entrance requirements and special preparatory programs) for ethnic Malays. The science courses in this program follow traditional disciplinary lines. Recently the off-campus program has also gained in popularity among young high school graduates. It is now estimated that by the late 1980s the off-campus program will cater to about 5% of the university population.

Finally, in the Philippines there are a variety of nonformal education programs in science education. One of the most lively is that of the science club. As of 1979 there were roughly 2500 science clubs in the Philippines with a total membership of more than 200,000. Many of these clubs have a practical problem orientation, such as developing food production schemes, developing new energy sources and conserving natural resources. Another fascinating example is the 'people's school' movement. Supported by the International Institute for Rural Reconstruction, this movement in the Philippines introduced new technology into depressed rural areas through a process of problem identification (using participatory research), leadership training, and a two stage technology transfer (from professionals to village representatives - 'barangay scholars' - and from them to other villagers through demonstration projects). The processes and the successfulness of these alternative schools are now being evaluated with the help of IDRC funds.

5. Research in Science Education

It is difficult to tell how much and what kind of science education research has been conducted in the region, especially since so much of it is unpublished and/or in local languages. From the documents available at this time it is apparent that at least the following kinds of research have been or are being conducted within the countries in the region: studies on the cognitive abilities/levels of pupils, curriculum evaluations, assessments of student achievement in science and related attitudes, studies of teaching-learning processes, studies to construct profiles of students and science teachers, community studies and action or participatory research.

RECSAM has for many years sponsored a program to assist countries in the region to assess the intellectual development of their children, especially as it relates to concept formation in science and mathematics. RECSAM's instructors in this program have promoted the use of clinical methods (sometimes called group task approaches), which were pioneered at the Geneva school under Piaget. The RECSAM project has involved developing, pilot testing and revising appropriate instruments in all ASEAN countries.

Three of the countries in Southeast Asia have been involved in the IEA network for the evaluation of science achievement (the Second International Science Study), namely, Thailand, Singapore and the Philippines. Besides assessing conventional areas of science knowledge and comprehension, the study is covering process skills of scientific inquiry (as far as they can be measured through a paper and pencil test). In addition to internationally coordinated analyses, Thailand expects to use the results as a sort of summative evaluation of its new curriculum. The Philippines, on the other hand, expects to use its results to ascertain whether or not its students are sufficiently prepared to meet the country's science and technical manpower needs.

In addition to the above, IPST in Thailand has made formative evaluation a strong component of all its curriculum development efforts. Using qualitative (direct observation) as well as quantitative methods (teacher questionnaires), IPST has produced over 50 research studies, which it has used in continuous curriculum renewal and improvement.

The Science Education Center at the University of the Philippines has turned out an impressive array of research studies, using a variety of methodologies. Its monograph series includes 5 studies on student characteristics related to science learning, 5 on science teacher characteristics and roles, 3 on the science curriculum, 3 on learning-teaching processes, 3 on student outcomes and one community study. In its work on the 'survival of the family', UPSEC used participatory research to assess community needs and to experiment with new village-level technologies.

In Singapore the Curriculum Development Institute (CDIS) encourages teachers to work as 'coagents' in continuously renewing the science curriculum. In addition, the Institute of Education has developed a unique institution referred to as TREP (Teachers as Researchers and Evaluators Project), which

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11RECSAM, Final Report, op.cit.

12The Science Education Center of the University of the Philippines has an annotated catalogue of publications available on request through Director, Dr. Delores Hernandes.
encourages teachers to conduct research in their own classrooms, e.g. performing simple learning experiments and assessing their results.\textsuperscript{13} Findings are then reported to IE which uses or disseminates them as appropriate.

Finally, in Indonesia some in-house evaluations of the two major science education projects have taken place. In addition, a major summative evaluation of the secondary science project is underway drawing on prominent national researchers as well as Dr. James Eggleston of Great Britain. Besides that some interesting dissertations on science education have or are being written, like Beverly Young's (British Council) 'illuminative evaluation' of science teaching and Ratna Wilis' (IKIP Bandung) forthcoming research into teachers' understanding of science process skills.

6. Regional Collaboration

A resurgence of interest in science education during the early 1980s has led to the proliferation of regional activities and exchanges. Unlike the first big post-independence surge in science education, which was tied to the concerns and problems of the Europe and the United States, the movement in the late seventies and early eighties is based on a concern for national and regional development.

At RECSAM 1980 was the culminating year of SEASAME (South East Asia Science and Mathematics Experiment) an eight year effort to work cooperatively in the development of 'indigenous curriculum reforms', in the spirit of 'interdependent independence'.\textsuperscript{14} Since then scores of conferences and workshops have been held at RECSAM, one of the most recent of which, the regional seminar on 'Problems and Issues in the Teaching of Primary and Secondary Science for Development' (June 6-10, 1983), resulted in the call for 'value-oriented' science as mentioned above.

The latest series of regional UNESCO activities in the science education field can be traced back to the UNESCO/ESCAP Conference of Ministers Responsible for the Application of Science and Technology to Development and those Responsible for Economic Planning in Asia and the Pacific (CASTASIA II). This conference produced the so-called Manila Declaration which contained 25 recommendations, including the need for member states to build up science and technology and R & D management

\textsuperscript{13} Information available at the Institute of Education through Dr. Sim Wong Kooi, Director, Singapore.

capabilities and to integrate science and technology development with national economic planning and policies.

A direct follow-up to that conference was a meeting held last month (December 12-15) at the ESCAP Regional Center for Technology Transfer in Bangalore (sponsored by the UNESCO Regional Science Office in Jakarta) to plan training programs to assist policy makers in transforming economic development requirements into science and technology programs and in finding appropriate applications for the results of research in science and technology.

Related to the CASTASIA declarations but also drawing from global strategies and plans are two other UNESCO initiatives, first the 'Science for All' movement, spearheaded by the UNESCO Education Office, Bangkok, and second the recent meeting concerning the 'Popularization of Science and Technology in Southeast Asia', organized by the Science Society of Thailand in cooperation with the UNESCO Regional Office for Science and Technology, Jakarta.\(^{15}\)

A meeting on 'Science for All' was recently held in Bangkok (September 20-26, 1983) to consider ways in which science concepts and attitudes could be 'delivered' to four specific target groups, namely, the formal school population, out-of-school children and youth, the work force (including illiterate adults), and the educated section of the populace. The rationale for extending the concept of 'all' to include target groups beyond the formal school population was based on a strong concern to establish a mechanism capable of creating and maintaining a positive climate for the ideas and endeavours of science, and any associated technology. Thus discussion centered both on the development of delivery systems for basic 'scientific literacy' and on shifting the teaching emphasis in schools towards establishing and maintaining a positive attitude towards science and technology.

The other UNESCO meeting focussed on four specific topics judged to be crucial to national development in the future, namely, informatics (computer applications), genetic engineering and biotechnology, marine resources development, and remote sensing for assessment of natural resources. Beyond that delegates pressed for a more comprehensive examination of science and technology needs in each country so that other topics might become the concern in future meetings. 'Popularization' in this forum had a very limited meaning — the development of a 'critical mass' of scientists, engineers and policy-makers to allow for national and regional infrastructural development and self-sufficiency in the above areas.

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\(^{15}\) The Science Society of Thailand, 'Summary of the Meeting on the Popularization of Science and Technology in Southeast Asia', 15-18 August 1983. Also available at UNESCO Regional Office for Science and Technology, Jakarta.
The above discussion on regional collaboration has been restricted to official meetings and regional institutions. Although such collaboration is perhaps useful in articulating themes and issues of common concern, there is also an unreal aspect to it — it exists more in terms of rhetoric and formal gestures than in terms of actions and enforceable policies. Moreover, there is a strong 'top-down' bias in all these forms of collaboration, science being defined by ruling elites and 'delivered' without discussion to schools and villagers.

In addition, participation in the follow-up to any such meeting will inevitably involve government ministries, never a very innovative or creative force. Even if imaginative initiatives were to emerge from such meetings, it is unlikely that their vitality would survive the pressures of politicization and/or bureaucratization at the national level. Perhaps more promising in this regard are the less formal interactions between scholars and activists through private channels or through such agencies as the Asian Institute of Technology (Bangkok), which promotes interdisciplinary research and training among scholars in the region emphasizing problem areas of recognized importance; activist organizations like the International Institute for Rural Reconstruction (IIRR) with its emphasis on 'people schools', and grassroots organizations like the Rural Institute for Community Education (RICE) located in the Philippines, which is developing a regional network of action researchers.

7. Issues and Reflections

Science education in Southeast Asia is a serious matter, perceived as important to directions of future national growth and development, capacities for personal and national problem solving and the creation of humane and egalitarian societies. Recently educators in the region have emphasized integrated, socially relevant, process skill and values-oriented science. They have placed great faith and an enormous burden on science.

Reflecting upon such trends one wonders if in fact too much isn't being expected of science. Should it or can it be the vehicle through which problem solving skills are transmitted and creativity promoted? Aren't other fields of study (philosophy, social studies, the arts) and other activities (extra-curricular activities, social action) just as (or even more) appropriate for promoting such skills and attitudes. Aren't there possibilities and dangers that science may be 'over sold', as perhaps is already the case in Singapore where achievement in science is used for screening the nation's leaders and corporate executives. Moreover, as a result of the activist's zeal to popularize science in rural villages as
a vehicle for problem solving, is it possible that people will begin to accept science as sort of a modern day magic only to become disillusioned later when it does not release them from poverty and deprivation?

One also wonders, after so many years of indigenous curriculum reform, whether there are any true examples of an indigenous science curriculum in Southeast Asian schools. Adopting an activity-oriented, discovery-based science is a significant reform, but in a sense it is simply exchanging an old imported model for a new one. Even when the trend is to tie science education to social issues, the issues raised (e.g. environmental pollution, consumerism, etc.) seem to have come out of the industrialized West. An even stronger point could be made of regionalizing curricula within nations. As much as Indonesia or the Philippines talks about science related to the local environment, such talk to date appears only to have resulted in the production of a few supplementary modules.

In short, it appears as if new science learning models have been adopted with little critical scrutiny or local adaptation. Whether this is a reflection of the perceived universal character of science, or a function of the sometimes subtle and difficult nature of the subject matter, or perhaps a commentary on 'dependent' character of science curriculum creators is not clear and would be an interesting area for future investigation.

A number of questions can also be raised concerning the recent trend to focus on process skills with the intent to create critical-mindedness, logical thinking and problem solving abilities. These may be worthwhile objectives, but there are doubts in many minds whether classroom activities alone can create them and whether their acquisition is consistent with prevailing cultural norms and values.

Research reviewed by a science educator in Indonesia, Ed van den Berg (1983), has indicated that in the West students who have been taught science with laboratory work have performed better on practical skills such as using lab equipment than students who have not done lab work, but have not performed better on tests of understanding of science concepts, ability to think scientifically (e.g. interpret and evaluate data, solve problems experimentally, etc.) and interest and motivation in science.16 Similarly a participant in the

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recent 'Science for All' Conference pointed out that most efforts around the world to use science courses in teaching process skills have failed (Fensham: 1983).

Van den Berg asserts that this apparent failure is to a large extent a result of the way lab work is typically done. In a similar vein, Fensham contends that large class size, a condition in all Southeast Asian schools, have made it almost impossible for teachers to create the appropriate atmosphere for discovery learning to take place. In addition, he asserts that students as well as teachers have been unable to abandon their need for simple structure, i.e. knowing the answers to science questions. Thus he contends, a kind of catch 22 situation prevails: 'If process skills are not associated with meaningful knowledge and content, they will lose value; if they are associated with meaningful knowledge content of science, they will be lost in the face of this content of worth and in any case they are not necessary aspects of its learning'.

Others have pointed out the power of the school examination in subverting any attempt to make science more process than concept learning. In Singapore, for example, the pressure for a good showing on the academically-oriented Cambridge exams is so strong that even though an emphasis on process skills and active learning has been placed in the new curriculum, most teachers cannot resist the temptation to teach didactically 'to the test'. In Malaysia, where the use of Cambridge exams has been abandoned in favor of national exams, attempts have been made to restructure exams to test process skills and related intellectual growth. However, results on such tests have been so disastrous that gradually they have become predominantly content-oriented again. (It will be interesting, to see what happens in Thailand in this regard, since exams there have been recently revised in the direction of process skills.) Since process skills are really not well suited for testing through paper and pencil tests, it may be that as long as single exam results are crucial in student selection, process skills will never be emphasized in practice ('the actual curriculum').

Finally, just a brief (over simplified) note about culture. In most Southeast Asian cultures children are taught to respect their elders and acquiesce to authority. Those in authority are expected to know all the answers; not knowing the answer is cause for 'losing face'. Great value is placed on social harmony and conformity. All of these factors mitigate against the successful application of discovery learning and the acquisition of critical mindedness. As the current head of

Singapore's Institute of Education, Sim Wong Kooi, said over 10 years ago, 'if children are not expected to question their elders at home, if teachers are expected to follow directives and not use initiative and depart occasionally from stipulated practice ... the widespread adoption of curricula that insist upon discovery learning is likely to be an impossible task or else merely a farcical practice'.

8. Possible future Research Directions

In relation to the issues raised above, a number of research questions have been formulated which should be considered for future action. Among them are the following:

1. What are important national and local problem areas to which science and science education could be applied/linked? Best addressed from the point of view of villagers or average workers (not university professors or ministry officials) perhaps through the use of participatory research.

2. What perceptions do villagers or urban workers (adults and children) have of science, its value and usefulness? Possibly addressed through qualitative research including in-depth, unstructured interviews.

3. To what extent are active or discovery learning methods actually being applied in the classroom? Requires direct observation.

4. Do children actually learn science process skills as a result of more active learning processes? A possible field experiment. Process skills perhaps measured through interpretive essays or practical tasks.

5. To what extent do teachers actually understand the processes of science? Surveys might be used here, but better ethnographic interviews.

6. Are parents and teachers becoming less authoritarian? (Survey research) To what extent has education (both its content and social environment) contributed to any such change? (Casual analysis) To what extent can educators capitalize on any such changes in order to make learning more student-centered? (Adaptive field testing).

7. What is more effective in promoting creative problem solving — experiences with art or drama, group outings or projects, experiences with scientific experimentation, etc. A series of experiments, might be performed.

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18 Nicholas Tang, op.cit.
'PEOPLE'S SCIENCE' AND DEVELOPMENT THEORY

Krishna Kumar
'Adoration of science' and 'fear of science' are the two responses to scientific and technological development prevalent in the current intellectual climate in India. Undoubtedly I have risked enormous simplification in summarising so drastically the two sides of a heated, keenly participated debate. Even if it were possible to do so, I would not like to resolve the debate, for, as I will show, the continuation of the debate is serving a purpose which neither science nor its fear could serve without help from the other. My aim is to clarify some of the issues involved in the debate by examining 'people's science' in terms of development theory.

What is 'People's Science'?

In a way 'people's science' is a misnomer, for it does not refer to the science people have but rather to the goal of taking the scientist's science to the people. 'People's science' is a growing movement, so its parameters are not yet drawn in a definitive sense, nor has its attempt to assimilate new questions and solutions stopped. The assertions by which one might choose to identify the movement cannot, therefore, be guaranteed to last, except in the case of a few strong ones. These strong assertions, in my view, are two: (i) the knowledge and benefits of science ought to be equitably distributed; and (ii) individuals working in science and technology establishments must understand the problems of the poor. Numerous voluntary groups are working throughout the country to popularise these assertions. Many of these groups have institutionalised themselves, some are working

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1 The current debate can be pursued by looking first at the 'Statement on Scientific Temper' (Mainstream, July 25, 1981), and then at the articles published in the August 29, October 10, November 14, and December 20, 1981 issues of Mainstream; Anil Sadgopal's 'Between Question and Clarity' (Science Today, October 1981); PPST Bulletin, March 1982; my Science Education and Development (CSDS, New Series no. 2, 1983); and the August 15, 1983 issue of Yojana. This is by no means an exhaustive list of references.

2 For a listing see Kannan (1979) and Jaffry et al. (1983).
within already established institutions. Although research literature on 'people's science' groups is meagre, programmes undertaken by them would take volumes to describe with any degree of analysis. This realisation alone suffices for me to accept the term 'movement' as a collective name for the activities of all the different science activist groups.

The purposes of 'people's science' movement are not so easy to discuss as are its salient assertions. Indeed, it may be inappropriate to search for common purposes in a movement which consists of so many independent groups and institutions. As one often sees in India, objectives are determined and clarified with reference to an adversary force. Thus, the discussions held at the Trivendrum convention (February 1983) of 'people's science' groups led to the recognition of two forces that the movement is opposed to. The first of these forces consists of godmen who oppress the poor socio-culturally by perpetuating supernatural and superstitious beliefs; the second force is that of capitalist development which is 'impoverishing the majority while enriching the few' (Jaffry et al., 1983) and is using science as a tool to manipulate people.

These two hostile forces provide a context to look at the specific objectives of the 'people's science' movement in a more detailed manner. The following is a list of objectives collected from bulletins and announcements of different science groups. Since no attempt has been made to sift, classify or collapse, the list may have overlapping and conflicting objectives. The objectives are:

i. to popularise scientific knowledge among the masses;

ii. to develop a scientific outlook among the masses;

iii. to challenge the forces of supernaturalism, obscurantism and superstition;

iv. to equip the poor with knowledge and skills to analyse and articulate their demands and rights in an effective manner;

v. to re-assess modern 'Western' science and technology which has grown mainly within the historical and economic context of colonialism;

vi. to re-evaluate non-Western or indigenous traditions in search of an alternative science and technology for our society;

vii. to develop appropriate technology and popularise it;

viii. to motivate professional scientists to work on problems that are relevant for the lives of the poor people;

ix. to involve science researchers, teachers, and students in mobilising the masses for structural change in society;
x. to build pressure on state structures to ensure that decisions are taken in a rational manner;

xi. to popularise self-reliance and the use of local resources in matters such as health, education, housing and industry;

xii. to develop a critical awareness regarding the methods used in the present system of education, and to develop an alternative method of education, especially science education, that would be relevant to children's own lives.

Four areas have been more popular than others among science action groups, and these are: health, education, environment, and appropriate technology. Several agencies have involved themselves with programmes in all four areas, while others have specialized in one or two. In the case of a large number of agencies, it is difficult to describe 'education' as a separate area of action, for it subsumes all other action programmes. Nearly every 'people's science' group has undertaken programmes in some or the other sphere of social action that would come under the broad rubric of 'non-formal education'. On the other hand, there are a few agencies that have developed a programme in science education under the formal or school system.

Paradigms in Development Theory

'There can be no fixed and final definition of development, merely suggestions of what development should imply in particular contexts' (Hettne, 1983, p. 7). This realisation helps us escape the welter of claims and counter-claims made whenever the meaning of 'development' is under discussion. From this point of view, all attempts to theorise on the process of development can be seen as voices in an international rhetoric. Three distinct paradigms can be identified among these voices: 'modernisation', 'dependency', and 'alternative development'.

Modernisation theorists have derived their philosophical orientation from the well-established tradition of structural-functionalism in sociology. Hoogvelt (1976) explains: 'Because modernisation theories have viewed the total transformation, that is Westernisation, of developing countries as an inescapable outcome of successful diffusion of the Western economic/technological complex, by methodological reversal it is argued that a reorganization of existing social and cultural as well as political patterns in anticipation of their compatibility with the diffused Western economic/technological complex may in fact facilitate the very process of this diffusion itself' (p. 60).

3Along with Hettne (1983), see Foster-Carter (1978), Kitching (1982), and Roxborough (1979).
Supporters of modernisation typically choose urbanisation, literacy rate, free enterprise, cultural secularisation, and social mobility as indicators of development. The key dialectic that the modernisation paradigm recognizes is between 'tradition' and 'modernity'. This dialectic is perceived as an endogenous process, facilitated by introduction of new ideas and their diffusion. Great emphasis is placed on attitudes and behaviour of the population.

'Dependency' paradigm emerged out of critiques of modernisation which proposed fresh application of Marxist theorising on imperialism. The rise of this paradigm in Latin American social sciences was preceded in India by activist scholars like Dad Bhai Naoroji and Rajni Palme-Dutt who had identified underdevelopment of the colony (i.e. India) as the basis of development in the colonizer's home (i.e. England). This historical linkage is now recognized by 'dependency' theorists as 'centre-periphery' relationship between the developed and the underdeveloped countries. The geography of 'centre' and 'periphery' is the basis of the international division of labour, skills, and knowledge. Since the poverty of the periphery is a product of the centre's wealth, the periphery cannot overcome poverty without altering the historically determined links with the centre.

'Compared to the endogenism of the modernisation paradigm, the dependency approach in its stress on external factors or the impact of the world context appears almost as an antithesis. However, with respect to the content of development the difference is slight' (Hettne, 1983, p. 46).

The content of development - of its process as well as its outcomes - is the focus of 'alternative development', the third paradigm which has also emerged out of critiques of modernisation and its consequences. The intellectual background of this paradigm lies in Schumacher's economics, Gandhi's emphasis on self-reliance and autonomy of communities, and the concern for protection of the natural environment. Although none of these orientations is an altogether new discovery, their use as a basis for identifying a counterpoint to modernisation has been accepted relatively recently, in the wake of superpower rivalry for similar gains, draining and destruction of natural resources, and escalation of misery among the poor throughout the world. The solutions to these problems, according to the 'alternative development' paradigm, can be found in structural transformation in favour of people's participation in decision-making, increased independence of communities, and physiocentric planning aimed at the development of appropriate technology.

'People's Science' and Development

Any populist movement can be expected to have diverse senses of direction, and 'people's science' is no exception. Co-existence
of contradictory directions and methodologies is also a common feature of populist movements, but one that affects the life and achievement of a movement. Looking at 'people's science' in terms of the three paradigms of development theory allows us to identify contradictions within the movement. Some of these contradictions may well be within the limits of accommodation at present; recognizing them now may help the movement to predict and organize future trends.

The impact of modernisation is most pronounced in the emphasis on changing people's outlook and attitudes. A corollary of this emphasis is the counterposing of science against tradition, especially those aspects of tradition which involve faith in supernatural explanations and godmen. This dialectic between science and tradition has implications not simply for the movement's objectives but also for its methodology, especially its methodology of communication with people. Who are the 'people' with whom science activists want to communicate? A report (Vaidyanathan et al., 1979) of the first all-India convention of science groups identifies 'people' as agricultural labourers, poor and small peasants, rural artisans, craftsmen, and urban workers. The obstacles science activists face while communicating with these sections of society are no different from the obstacles any social agency would face, including state-sponsored social work agencies and professional educators. These obstacles originate in the economic and educational distance between the 'people' and the agents of change, and in the pattern of links that dominant culture permits across the distance. Nothing hurts the possibility of communication more than the spirit of patronage in the agents of change towards those whom they want to change. The attitude of patronage takes many forms; in the professional educator it arouses the urge to 'enlighten' the child; in the social activist it becomes the mission of moulding people in the image of the moulder. If the moulder has something called a 'scientific temper', he decides that the people he is working for must also have this temper.

Scientific temper, or for that matter any other behavioural characteristic, cannot be made a universal requirement without incurring a serious danger of undermining both its meaning and the autonomy of those who do not share that meaning. Those who argue, such as eminent writers in the August 1983 issue of the government periodical Yojana, that the lack of a scientific temper is the root cause of India's problems should consider the possibility that they may be oversimplifying. Can any behavioural trait explain the rise or fall of the fortune of a group of people? 'People's science' activists who have so far been ready to follow the lead given by the godmen of modernisation should review their commitment to a simplistic explanation of the problems faced by the oppressed.

The emphasis on changing people's outlook from 'traditional' to 'scientific' is not consistent with some of the other
objectives that can be identified in the 'people's science' movement. These other objectives are the ones that refer to the sociology of present-day scientific knowledge and the historical conditions under which much of it was produced. All science action groups are concerned about the concentration of scientific knowledge and technology in the powerful countries and in the hands of the local elite of the Third World countries. 'People's science' activists want a fair distribution of scientific knowledge and technology, and for such distribution to occur they feel that scientists would have to change their First World orientation in selecting research problems. Present day trends in problem-selection and dissemination of research are a product of the colonial heritage of international economy and education. Colonial exploitation has rendered today's Third World dependent on the First both materially and intellectually. The scientific community of the Third World is by and large a 'periphery' to the 'centre' which exists in the wealthy countries. This realisation on the part of 'people's science' groups corresponds to the main thesis of the 'dependency' paradigm in development theory.

There is an obvious conflict between the aim of liberating people from the bonds of tradition and the aim of liberating them from the bonds of colonialism. Overemphasis on backwardness of tradition may leave people with nothing to be proud of. Was not attack on people's self-image a weapon of the colonizer? This is why we need more accounts of pre-colonial science and technology in India of the kind Claude Alvares and Dharampaul have provided. It would be unfortunate if such valuable research is co-opted by revivalists to promote the notion that modern science is Western, therefore alien; and that India must pursue its own science to fulfil its destiny.

Research on indigenous traditions of science and technology would serve a useful purpose if it encourages and enables 'people's science' groups to materialise 'learning from people'. At present, such learning mostly consists of wishful thinking and vague, experiential gains. Since the recognition of Paulo Freire as an indispensable social action thinker, all kinds of agencies involved in social education have included 'learning from people' as one of their operational principles. Yet, the evidence pointing towards specific learning acquired from rural people is meagre. The few attempts that have been made in this direction suggest that people may be less reluctant to teach what they know than scientists are to learn. If 'people's science' groups

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4A recent article that helps us understand the sociology of dissemination and recognition of science research is 'Science in the Third World' by Eugene Garfield in *Science Age*, October-November 1983.

truly believe in learning from people, they would have to take up systematic programmes of research in specific areas of traditional knowledge; as a posture, 'learning from people' has already become cliche just as much as 'grassroots', 'field', and 'testing' have become.

Emphasis on the content of change that one finds in the 'alternative development' paradigm is reflected in the demand for the production and dissemination of appropriate technology that a large number of 'people's science' groups have either themselves voiced or have supported. This demand is consistent with another aspect of both 'people's science' movement and the 'alternative development' paradigm, namely, that people's viewpoint and participation should play a key role in decision-making by the state. Big technology has led to centralisation of decision-making, rule by experts, and the end of autonomy for large communities of people both literate and oral throughout the world. The demand for scaling down of large-scale technology and scaling up of traditional technologies (McRobie, 1981) aims at enabling people to reclaim their independence from symbolic and material control by 'centres', both local and global. However superstitiously the prophets of modernisation may look at appropriate technology, it certainly promises greater health for democratic institutions than modernisation could deliver.

Science as Symbol

'It is very difficult for anybody to take an open anti-scientific attitude', says a brochure of the Kerala Sastra Sahithya Parishat while explaining the attitude of political parties towards the Parishat's work. Truly, science has become a symbol of all that is sacred and true for the modernised, and although few among the modernised actually throw the unscientific out of their lives, no one who is active in public life - from local to the highest level - fails to appreciate the point that science is a useful god, and further that this god can be kept pleased with lip-service alone. The holy status science is accorded by public figures makes it a fine tool for the social activist. It renders the activist almost as immune to criticism and persecution as would be the programme of a local council for the protection of cows or the megaphonic recital of the Ram Charit Manas. The security that science enjoys in contemporary India is matched only by the security that religion enjoys. What use have the science activist groups made of this security?

6 Apart from numerous examples of 'unscientific' behaviour by Indian scientists and advocates of the scientific temper that appear in Indian newspapers and some of which have been referred to in Yojana (August 1983), I find a photograph published in the International Herald Tribune of September 12, 1983 of great interest. This photograph is taken in Asia's technological giant, namely, Japan. It shows a throng of Japanese men standing beside their newly purchased cars waiting outside a temple to get their cars purified.
By accepting the symbolic value of science as its major political value, 'people's science' groups may find it possible to relent in their demand for the dissemination of the scientific temper among the masses as a pre-condition for social transformation. On the other hand, they may find it more necessary to toughen up their demand for the use of scientific information and procedures in the method of decision-making and implementation of decisions by the ruling elite. They may even be tempted to objectively probe the social and political dimensions of the examples of the scientific temper that scientists provide when they underplay the hazards of nuclear energy, DDT, and overdrugging. The socio-political behaviour of scientists and the science worship of powerful bureaucrats and politicians deserve harsher scrutiny than the temper of the oppressed masses.

The real use of a scientific temper and method for the study and transformation of society would perhaps be found in a different quarter than where science activists and their mentors have been used to applying it. The maverick editorial of Yojana's special issue, to which I have already referred, ends by saying that the scientific temper will enable our masses to 'comprehend what really underlies the cliches "Unity in Diversity" and "Tolerance Our Heritage"'. The political acumen and sense of political reality required to probe such cliches is rare among torchbearers of the scientific temper. In the quicksilver world of Indian politics, lines of rhetoric and alliances shift before sincere individuals in the academic fringe may always want to take note of. Today, science is the door through which oppressive and unwanted technologies and militarist research penetrate in the Third World with the help of its local elites. Consider, for instance, the current threat posed to the poor Indian education system by the powerful campaigners of micro and video technology. Their voice is heard and their products will be purchased in the name of science. The well-meaning propagators of science and its tempers are politically out of date. They have been outwitted by revivalists at home and by the corporations abroad. The cause of science is badly in need of a new elite. The 'people's science' movement would serve a historical role if it leads to the emergence of a new elite among the allegedly backward.
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GOVERNMENT SCIENCE & ENVIRONMENTAL ACTION:

THE CASE OF FORESTRY IN INDIA

Vandana Shiva
1. The growth of modern science is supported by four assumptions about its structure and dynamics.

   (a) **Universalism** - That claims of modern science are universally valid.

   (b) **Objectivity** - That claims of modern science are generated neutrally, independent of bias towards particular interests, and are valid for all groups and classes of society.

   (c) **Progressiveness** - That the growth of modern science is inherently progressive both as knowledge (better truth claims) and as practice (better and more prosperous quality of life).

   (d) **Epistemological Superiority** - That modern science is epistemologically superior to other systems of knowledge (which are viewed as 'unscientific', 'irrational' and 'ineffective').

2. All four assumptions supporting modern science are false. They are myths which provide the ideological underpinnings of modern science, ensure its growth, and protect its interests of monopoly and self perpetuation.

3. To establish that modern science has none of the above characteristics, we will take the case of forestry science. In spite of the low prestige enjoyed by this discipline in the hierarchy of modern science, it remains central to survival in tropical ecosystems.

4. Forests are central to survival because they stabilize and maintain supplies of essential resources like water, soil, food, fodder, fuel, timber, medicines.

5. People have had knowledge of forestry for centuries and have used this knowledge to select those species from nature which are most useful for human needs. Such a selection of species suited to the local ecology has been the basis of traditional 'farm forestry' or 'agro forestry' or 'social forestry'.

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**GOVERNMENT SCIENCE & ENVIRONMENTAL ACTION:**

**THE CASE OF FORESTRY IN INDIA**

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The beginning of 'scientific forestry' is associated with the beginning of modern forest management by which the state appropriated control over forest resources from the people to exclusively serve commercial timber interests.

Indian forestry is an extension of models and concepts developed in temperate countries. However, tropical forests are completely different from temperate ones in their complexity and fragility and their functions. The temperate zone forestry is not universally valid and its universalisation can only spell ecological disasters in tropical systems.

Indian forestry is not objective. It has been generated as a response only to timber interests. The species selected are useful only as raw materials for forest based industry. They are highly unsuitable for soil and water conservation, and have no role in satisfying basic needs. The choice of Eucalyptus as the dominant species for afforestation both in reserved forests and on farm land is the most glaring example of how a species only suitable for pulp-wood is being propagated at large scale. The myth of universalisation is used to indicate that this species is suitable for all ecozones, and for all uses and functions of trees for all classes. The myth of objectivity covers up the bias in its selection, mis-guides and mis-informs the people about its ecologically hazardous implications in arid zones. The bias in forestry research first leaves out knowledge of most indigenous species so that no objective basis is available within modern science to judge whether claims made about an introduced species are true or not. The bias in forest management then suppresses the knowledge that might prove a hindrance to its commitment to serve commercial interests. Thus no research on the ecology or uses of traditional trees has been done. On the other hand, the limited research which establishes eucalyptus to be ecologically hazardous because of its unusually heavy water and nutrient demand has been systematically suppressed. Forestry science can lay no claim to objectivity either in its context of discovery or its context of justification.

Afforestation guided by this limited and biased knowledge has worsened the resource situation. It has depleted water resources, soil fertility, created a crisis in food production and fodder supply. As social forestry it is leading to an irreversible collapse of rural ecosystems. Forestry science cannot claim to be progressive for society at large.

Knowledge systems which have been declared unscientific are capable of better management of forest resources on a sustainable basis, satisfying diverse needs in a balanced manner. Indigenous knowledge leads to low cost, ecologically balanced, economically sustainable and productive options in forestry. Farm forestry based on 'tamarind' or 'neem' has multiple functions, is sustainable, and leaves the environment richer. 'Social forestry'
based on the experts, prescription of eucalyptus monoculture destroys diversity of farm trees and food crops, mines the fertility of the soil, destroys renewability of water resources, provides no inputs of fodder, fertilizer and structural timber. Eucalyptus farming spreads because it is an 'ecological narcotic' - it leads to addiction. For every 6 big farms in Karnataka planting eucalyptus on agricultural land, to avoid labour management problems, 12 small and marginal farmers are being compelled to go in for eucalyptus farming because the high nutrient and water demand of eucalyptus is making it impossible to sustain food production. Eucalyptus is thus becoming a threat to survival of the landless and the small peasant. An epistemologically inferior knowledge system is growing because it is killing the ecological base of alternative epistemologically superior knowledge systems.
INVESTMENT AND OVERINVESTMENT

IN SCIENCE EDUCATION

Nicholas Tang Ning
INVESTMENT AND OVERINVESTMENT IN SCIENCE EDUCATION

1. Science Education in Singapore

1.1 Historical development

The first significant document pertaining to science education in modern Singapore was the 1956 Report of the All-Party Committee of the Singapore Legislative Assembly on Chinese Education. This report recommended that emphasis be placed on the learning of science and mathematics to meet the requirements of an industrialised society. Hitherto, the main form of science taught in schools was Tropical Science which was primarily concerned with the health and hygiene of the individual. The only exceptions are a few elite (mainly missionary) schools which could afford the facilities and equipment necessary for General Science.

The recommendations of this committee were not, however, implemented until 1959 when Singapore achieved full internal self-government. This Government, which has remained in office ever since, firmly believes in the Human Capital Theory (Schultz) and, hence, started a massive education expansion programme. Furthermore, it also decided that the only solution to the economic problem (particularly unemployment) was industrialisation. Therefore, the main emphasis in the education programme were

'\(a\) Development expansion in technical education; \\
\(b\) Stress on the teaching of science and mathematics; and \\
\(c\) Emphasis on bilingualism.'

(Lau, 1978, p. 30)

Although almost all agreed with the first two areas of emphasis, the bilingual policy has always been a controversial issue. The main argument put forward by the Government, in support of this policy, is that English is the language of science and technology. If Singapore hopes to learn from the industrialised West and 'plug' itself into the world economic system then English must be taught in all schools. How much this has contributed to the economic growth of Singapore is an interesting area for further research.
The first move to popularise science was in 1959, when science became a compulsory subject for all pupils in the primary and lower secondary classes. In 1978, science became compulsory for all upper secondary classes.

An interesting development occurred in 1982, when it was decided that science will no longer be compulsory for the lower 40% of the pupil population in the secondary schools. This was introduced as part of the New Education System (NES) where the main feature is the streaming of pupils into different courses from the third year of education. The main purpose was to allow each pupil to progress at a pace most suited to his intellectual ability. It is hoped that this could be achieved by providing different curricula for the different courses. The weaker pupils will also take a longer period to reach the same terminal examination. For example, the better pupils will take 6 years before sitting for the Primary School Leaving Examination while the weaker pupils will take 8 years, without repetition in any one level.

1.2 Status of science

When one discusses the status of science in Singapore secondary schools, one will need to divide the science subjects into two main groups. The first, and high status, group consists of the 'pure sciences' (Biology, Chemistry, and Physics) and, till recently, Physical Science. The second group consists of General Science, Human and Social Biology and, recently, Physical Science. In fact, pupils offering any one of this

1 Under the NES the students in the slower courses follow syllabuses which cover about 60% or less of the corresponding syllabuses for the more able students. This arrangement, instead of having totally different syllabuses, was a political decision rather than based on any educational theories. This new education system was able to secure parliamentary support because it has always promised that every child will still have the opportunity to sit for the GCE O-level if he performs well in his examinations. Therefore, the syllabuses for the weaker pupils must remain subsets of the syllabuses for the better students. However, personally I see this compromise as very unsatisfactory. What the weaker students are receiving is a 'watered-down' curriculum which does not make much sense to either the child or to the subject specialist.

2 Physical Science was introduced in 1969, with the aim of ensuring that students receive a broad education at the secondary level. By 1974, all science students had to offer this subject and the 'pure' sciences (i.e. Biology, Chemistry and Physics) were no longer available. However, due to pressures from mainly the University, the teachers and a small group of parents (who found that many universities in the U.K. and the U.S. do not accept this subject) this decision was reversed. From 1982 onwards, the 'pure' sciences were available again at the GCE O-level examination. As a result, Physical Science is no longer a high status science, but is now being offered by the 'sub-science' classes in most schools.
latter group of science subjects are usually called 'arts students', or 'sub-science students' if they offer Physical Science.

The university, technical institutions and some employers are partly to be blamed for lowering the status of the second group of science subjects. A pupil with even a very good pass in General Science, for example, will not be able to qualify for most of the science courses in the university and polytechnics. Even Singapore Airlines insists that their prospective pilots must have a GCE O-level pass in either Physics or at least Physical Science.

The only reason why pupils continued to offer these lower status science subjects is because of the compulsory science policy. Now that this policy is no longer valid for the less able pupils, it may be interesting to see the fate of these subjects. But an even more interesting question is whether these 'arts students' would have been less "complete" in their education, or less productive workers, if they had not offered these science subjects. My personal view is that the impact on these 'arts students' is insignificant because most of these students tend to do so badly in science for one reason or other. I believe that the same scientific processes that these pupils ought to have picked up from these science subjects, could have been taught through subjects such as Geography or Philosophy, which they may do better in.

It is difficult to say exactly when did science (and henceforth I shall be referring only to the 'hard' sciences in the first group) become a high status subject in the schools. However, as early as the early sixties, almost all pupils would try their very best to get into the science classes. No research has been done to identify the factors that led to this swing towards science. Many assumed that the only reason is the encouragement given by the Government. However, based on personal observation, I believe that there are other more subtle pressures at work.

1.2.1 Owing to the lack of facilities and resources it was deemed necessary to restrict the number of science students. The practice of almost all schools is to select the pupils based on their overall performance at the school examinations. Not only was this a 'neutral' way to select the students, it was also thought to be the most logical way since 'science is too difficult for the less able pupils'. This assumption was never challenged by anyone - not even principals or teachers who were trained in the humanities. As a result, the science students became an elite group in all schools. Therefore, every child strives to join this group regardless whether there is a genuine interest in that subject.
1.2.2 The desire to belong to an elite group may not be the only reason for all pupils (and parents). Many may be motivated by the fact that science students have a wider choice of jobs. Science students, for example, can go into administrative jobs while an arts student cannot be a technician or engineer.

Furthermore, a pupil who offers science in the GCE O-level can opt to do an Arts course in the A-level if he so chooses. But this is not so for an arts student. Similarly, a science student could still switch to an Arts or Law course when he enters the university. Hence most pupils would like to keep their options open for as long as possible.

1.2.3 The popular images of science and scientists may also have an influence on the young minds. Science is often associated with 'modernity', with the change to discover or invent new things, and is the magic that will solve all problems. The scientist that experiments with chemicals that will go 'boom' or designs 'Mellenium Falcons' is a particularly appealing image to the boys. On the other hand, the arts subjects are often regarded as boring, a lot of mugging and reading. I believe that this perception is more important to pupils in the secondary school level than most researchers would admit; though many students may later find that their perception is totally wrong, and this may be one factor for their poor performance in science.

As a result of these factors, the popularity and demand for the science courses snowballed. The better pupils go for science and as a result these science students tend to do better in life, which in turn creates the impression that it is science that is responsible for their success. Although this phenomenon did popularise science education, it also created a number of unanticipated side-effects which will be discussed in Section 2.2.

1.3 Science syllabuses

There have always been three nation-wide examinations in the Singapore education system. The first is the Primary School Leaving Examination (PSLE) (equivalent to the 11+ examination). This examination is set and marked locally. The other two are the GCE O-level and A-level examinations which are conducted by the Cambridge Examination Syndicate.

The syllabuses for the primary and lower secondary science are, therefore, designed in Singapore. However, the syllabuses for the upper secondary and the pre-university classes are determined by Cambridge. These Cambridge syllabuses, in my
opinion, are very academic. They probably need to be so because the GCE 0- and A-levels were designed for the top 20% or 25% of the British population - the group that would be expected to go on to the universities. The less able in Britain would sit for the CSE examinations.

But Singapore, up till now, has only one examination at the 16+ level for the whole ability range. Of these, about 20% will go on and sit for the GCE A-level examinations. In other words, everyone had to follow the academic syllabuses of Cambridge.

Although many attempts have been made to make the primary and lower secondary syllabuses less academic, it has always been constrained by the concern to adequately prepare the pupils for the all-important GCE O-level examinations. An example was an attempt in the sixties to make science more relevant to the child by teaching it through language lessons - an integrated approach to learning. The project, called the Pilot Primary Project (PPP), failed after a few years, although it received very favourable reactions from other countries. One of the reasons for its failure was that teachers and parents say that there was insufficient 'learning' and they dubbed the project as 'Play, Play, Play'.

In other words, even the primary and lower secondary syllabuses have been very academic in nature; namely, the accumulation of scientific facts.

The latest attempt is the new syllabuses which were introduced in 1980 for the primary and lower secondary levels. In theory these syllabuses were an attempt to move away from the mere accumulation of factual information to the learning of 'scientific processes'. However, the designers of the syllabuses as well as the writers of the textbooks seem to be unable to ignore completely the demands of the GCE O-level; hence, academic knowledge. Very often an important (if not the most important) criterion for the inclusion or exclusion of a topic or piece of knowledge is whether it is required for the GCE O-level examination.

3 From 1984 onwards there will be a GCE N-level examination. This new examination is designed for the less able students under the NES. It is designed in such a way that almost all candidates will pass, but only about 20% will be able to do well enough to allow them to proceed to the GCE O-level examination at the end of the next year. This innovation is interesting because effectively it has made the GCE N-level (this name itself is a stroke of genius) the terminal examination for the majority of the weaker pupils. But at the same time it has allowed the Government to keep its promise that every child can go as far as he is able to, if he does well enough at every stage.
These new syllabuses also require teachers to adopt an activity-centred approach; an entirely new role for many teachers. This change is still being resisted by teachers and some of the probable reasons will be discussed in the next section.

In a nutshell, Singapore's science syllabuses have been and will, in all probability, continue to be very academic in nature. As mentioned earlier, even the syllabuses for the less-able students are subsets of the same academic syllabuses.

1.4 Science in the classroom

'Some teachers insist on covering "so many pages" of the textbook per session and force pupils to do experiments of a "verifying" nature. The possibility of finding a solution (or a number of solutions) to a given problem is lost sight of. Beautiful diagrams and formulae are drawn on the blackboard and are studiously copied by the pupils into their notebooks. Occasionally class demonstrations are arranged by the teacher, but here again it is often to show "proof" of a statement, and not to discover the underlying principles through first hand observations by the pupils themselves. The result is that the pupils think of the laboratory session as a necessary chore, not of great value, to be "dodged" or "palmed off" to one's partner, whenever possible .... Often the more vigorous or keener pupils monopolise the practical work, and the weaker pupils who need it most find themselves learning off "by heart" results of experiments for the purpose of passing examinations. The end of these efforts, even when the pupil somehow gets through, is a permanent distaste for the subject, and what is worse, a firmly entrenched "idée fixe" that "science" is just a catalogue of unrelated facts, just like dates in a history.'

(Singapore, 1964, p. 61)

The above quotation may have been taken from a 1964 document, but most science educators in Singapore would agree that it describes very accurately what is still happening in a typical science lesson. Unfortunately, since 1964 no public document has been written about the way science (or any subject) is being taught in schools. But a recent incident could reflect the concern many science educators have regarding the way science is being taught. Since 1981, Cambridge has been trying to persuade Singapore to do away with the Practical examination for the O- and A-level examinations. It seems that Singapore is now the only country still offering this practical examination. However, the authorities decided against this because it was feared that if the practical examinations were removed then many teachers may not even bring the students to the laboratories at
all; even demonstrations may become obsolete. Although Cambridge has introduced questions in the theory papers that test laboratory skills, one cannot deny that these could be taught during 'theoretical' lessons. It may even be more efficient if the teacher tells the students what would happen rather than to allow them to 'discover' it for themselves. In fact, the feedback regarding the new primary and lower secondary science seems to indicate that this is precisely what is happening in the schools. Teachers are telling the students what they would observe if they had done what the worksheets ask them to.

In other words, in spite of totally new syllabuses and curriculum materials, produced at a very high cost, the dominant method used in the classrooms is still chalk-and-talk.

What are the possible reasons for this? Some of them, in my opinion, are:

1.4.1 Teacher ability. Beeby's classic book (1966) suggests that a teacher's lack of knowledge of subject matter forces him to cling

'desperately to the official syllabus, and the tighter it is the safer he feels. Beyond the pasteboard covers of the one official textbook lies the dark void where unknown questions lurk. The teacher is afraid of any other questions in the classroom but ones to which he can be sure of knowing the answers.... Activity methods and childish research are shunned because they lead all too easily to the brink of the unknown; group methods can be tolerated only if a group leader is satisfied .... to ask the stock questions and accept the stock answers.'

The table below shows the academic qualifications of the teachers and the level they teach. Furthermore, the latest statistics show that more than 30% of the primary school science teachers do not have any pass in a science subject at the O-level (Singapore, 1983). This weakness could be traced to the rapid expansion of education and could be one of the main reasons for the didactic approach.
HIGHEST ACADEMIC QUALIFICATION AND LENGTH OF SERVICE OF TEACHERS
BY SEX AND LEVEL TAUGHT
As on December 1982

<table>
<thead>
<tr>
<th>Qualification</th>
<th>PRIMARY</th>
<th>SECONDARY &amp; PRE-U CENTRE</th>
<th>JUNIOR COLLEGE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>MF</td>
<td>M</td>
</tr>
<tr>
<td>Below School Certificate</td>
<td>116</td>
<td>162</td>
<td>278</td>
<td>45</td>
</tr>
<tr>
<td>SC/GCE 'O' or Equivalent</td>
<td>2778</td>
<td>5677</td>
<td>8455</td>
<td>1433</td>
</tr>
<tr>
<td>HSC/GCE 'A' or Equivalent</td>
<td>301</td>
<td>191</td>
<td>1492</td>
<td>918</td>
</tr>
<tr>
<td>Pass Degree</td>
<td>25</td>
<td>27</td>
<td>52</td>
<td>770</td>
</tr>
<tr>
<td>Honours Degree</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>189</td>
</tr>
<tr>
<td>Masters Degree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>3220</td>
<td>7058</td>
<td>10278</td>
<td>3399</td>
</tr>
</tbody>
</table>
1.4.2 Evaluation of teacher. The above factor may be true for most teachers in the primary schools and some in the secondary schools. But it fails to explain why even suitably qualified teachers favour the didactic approaches. One key factor may be the way a teacher is being judged. In Singapore, as in many other countries, a good teacher is often one who produces the best examination results. Since the traditional paper and pen examinations are primarily concerned with academic knowledge which could be taught 'theoretically', teachers have found their traditional methods most efficient. More facts could be transmitted in the same length of time through expository methods than through 'discovery' methods. Therefore, teachers are actually being rewarded for sticking to the chalk-and-talk methods.

1.4.3 Purpose of education. The two factors described earlier could be traced to the society's view of the purpose of education. One could assert that if a society overemphasises the role of education as the developer of human resources, then schools will tend to be unduly concerned with certification which, in turn will encourage teachers to teach towards examinations. The irony here is that the very reason which has promoted science education is also responsible to a very large extent for the 'bad' way it is being taught.

1.4.4 Perceived role of teacher. Traditionally the teacher in a Chinese (and perhaps other Asian) culture is regarded as the disseminator of knowledge. The 'tze fu' (master) is the source of knowledge and the good disciple is one who would sit at his feet and receives what the former deems he ought to know. This tradition runs counter to the 'discovery' approach where the teacher takes a less dominant role; the main function is to arrange the environment to facilitate pupil learning.

Related to this is the authority structure of a traditional Chinese family. The father (and to a lesser degree the mother) is regarded as the person who knows everything and makes all decisions. Inquiry science challenges this structure. For example, the concept that objects could be classified in different ways according to different keys encourages a child to challenge a father's 'classification key' in other areas. The pursuit of objectivity, open-mindedness, skepticism, etc., are 'scientific attitudes' which may not be easily accepted by the society which is itself authoritarian since it is made up of such families.

Some people have observed that this authoritarian power structure is slowly being replaced by a more open structure. How much of this could be attributed to the influence of the schools' emphasis on science education is an interesting area for further study.
1.5 It is undeniable that science is a very popular subject in Singapore, and has a very high status in the eyes of most educators, parents and teachers. Some of the factors that led to this status and popularity were discussed.

However, it was also shown that the science taught in Singapore has traditionally been very academic, and is really suitable for the few who intend (or can continue) to pursue this subject in the institutions of higher learning. Furthermore, most teachers continue to adopt expository methods in the classrooms. Hence one could be tempted to conclude that the quality of science in Singapore is very low, if one uses the trends in science education as advocated by the Western world as the yardstick. The next two sections shall attempt to show that this need not be so. The first section shall show that perhaps science as a selector of talent is a more important function than as a developer of human resources in developing countries. But if one insists that science ought to remain as a developer of human resources, then perhaps there is a need to talk about appropriate science; appropriate for the needs of the economy and for the individual. The subsequent section shall explain this idea of 'appropriate science for all'.

2. Functions of Science Education

It has always been assumed that science education is the sine qua non of industrialisation. But this is a very expensive assumption. In Singapore, it costs about S$ 700,000 (approximately US$ 350,000) to equip the laboratories of a standard secondary school of about 1,500 pupils. This does not include the permanent fixtures such as benches, water and gas pipes, cupboards, etc. Furthermore, the size of the laboratories is about double that of a normal classroom, hence taking up more land and higher building costs. Even in terms of recurrent costs science programmes would use about 20% of the total annual expenditure of schools. Is this huge expenditure justifiable? This section shall attempt to look at this assumption from different perspectives.

2.1 Science as the developer of human resources

This is the most common exhortation and hope of almost all developing countries, including Singapore. But in reality the relationship between these two activities are more complex and unclear. Take Singapore as an example.

When Singapore embarked on its industrialisation programme in 1960 its main and primary concern was to solve the employment problem. The strategy adopted was, therefore, to attract labour-intensive industries (Goh, 1978, p. 128). These industries do not require highly-skilled workers at all;
definitely not workers with a science education. As Singapore moves up the technology ladder, however, the demand for scientific manpower also increases. But the number required still remains very small in terms of the total workforce. Table 3.1 below shows that even in 1980 when Singapore has already come a long way, the number of professional and scientific manpower is very small.

Table 3.1  Singapore Citizens by Highest Qualification
(Taken from Census of Population 1980, Release no. 3)

<table>
<thead>
<tr>
<th>HIGHEST QUALIFICATION</th>
<th>PERSONS</th>
<th>MALES</th>
<th>FEMALES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>1,479,484</td>
<td>746,995</td>
<td>732,489</td>
</tr>
<tr>
<td>NO QUALIFICATION</td>
<td>527,844</td>
<td>207,143</td>
<td>320,701</td>
</tr>
<tr>
<td>PRIMARY</td>
<td>648,475</td>
<td>374,490</td>
<td>273,985</td>
</tr>
<tr>
<td>SECONDARY</td>
<td>190,729</td>
<td>96,669</td>
<td>94,060</td>
</tr>
<tr>
<td>General GCE O-level</td>
<td>181,490</td>
<td>88,927</td>
<td>92,563</td>
</tr>
<tr>
<td>Technical</td>
<td>9,239</td>
<td>7,742</td>
<td>1,497</td>
</tr>
<tr>
<td>UPPER SECONDARY</td>
<td>83,200</td>
<td>49,819</td>
<td>33,381</td>
</tr>
<tr>
<td>General GCE A-level</td>
<td>52,111</td>
<td>27,753</td>
<td>24,358</td>
</tr>
<tr>
<td>Teacher Training</td>
<td>6,729</td>
<td>2,782</td>
<td>3,947</td>
</tr>
<tr>
<td>Technical/Commercial</td>
<td>24,360</td>
<td>19,284</td>
<td>5,076</td>
</tr>
<tr>
<td>TERTIARY</td>
<td>29,236</td>
<td>18,874</td>
<td>10,362</td>
</tr>
<tr>
<td>*Building &amp; Engineering</td>
<td>4,286</td>
<td>3,979</td>
<td>307</td>
</tr>
<tr>
<td>*Physical &amp; Natural</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sciences</td>
<td>5,539</td>
<td>3,661</td>
<td>1,878</td>
</tr>
<tr>
<td>*Medical Sciences</td>
<td>2,179</td>
<td>1,508</td>
<td>671</td>
</tr>
<tr>
<td>Humanities</td>
<td>14,754</td>
<td>8,253</td>
<td>6,501</td>
</tr>
<tr>
<td>Others</td>
<td>2,478</td>
<td>1,473</td>
<td>1,005</td>
</tr>
</tbody>
</table>

* Scientific and Technical manpower

It is interesting to note at this point that Pang Eng Fong, the Director of the Economic Research Centre at the National University of Singapore, states that the evidence clearly showed that,
'Singapore began to "take off" before there was time for educational changes designed to promote industrialisation to have any effect. Singapore's rapid development preceded the large scale expansion of technical secondary and tertiary schools. Firms accommodated to what was available.'

(Pang, 1982, p. 45)

According to Pang, the more important factors that contributed to Singapore's economic growth are really,

(a) political and social stability;
(b) willingness to accept and learn from foreign firms; and
(c) government intervention.

The fourth significant factor is perhaps identified by the sociologists - the 'migrant spirit'. Since almost all the early settlers were recent migrants from other Asian countries,

'the average Singaporean is highly resilient and adaptable holding no strong principles and adhering to no strong traditional values which can serve as strong obstacles to change. Change is quickly accepted and incorporated into his way of life'.

(Eng, 1983, p. 16)

In the late seventies, Singapore decided that it could no longer continue to depend on the low skilled labour-intensive industries. Steps were taken to restructure the economy and to attract high technology industries. One important feature of this restructuring is the greater use of computers and robotics to increase productivity and to reduce the use of manpower. But would it be possible for Singapore to move up the technology ladder had it not been for its education policy, in particular the success of its science programme?

It is equally important to notice that the actual number of scientific manpower in Singapore is very small. By scientific manpower I refer to those who have obtained a tertiary education in science and/or technical training. Recent trends seem to suggest that even for the middle level technicians, an academic science education is not entirely necessary; mathematics seems to be a more important subject.4

The question that arises, therefore, is whether the traditional academic science is appropriate for all? Or should

"The Economics Development Board (EDB) has recently jointly set up three institutions, to train middle level technicians, with the Governments of France, Germany, and Japan. The entry qualifications to these institutions are English and Mathematics - science is not a pre-requisite."
this form of science be reserved for the small group of scientific manpower that the country needs? This idea of appropriate science shall be discussed in greater depth in Section 3.

2.2 Science as a selector of talent

Talent could be selected in different ways in different societies. In meritocratic Singapore the primary instrument is performance at academic examinations. A person's worth is dependent to a very large extent on his academic qualifications.

Science seems to be a very good discriminator. A good science student is often also good in other subjects, while a poor science student seems also to be poor in other subjects. On the other hand, a pupil who is good in, say, History need not do well for science or mathematics. In other words, the ability to do well in science is often associated with a high IQ.

Hence it would seem possible that one of the major contributions of science to national development may well be that it is able to identify the talent necessary to run the country. In fact, this has already happened in Singapore. Many of the politicians, top civil servants, and administrators were science students. Take the Ministry of Education as an example. The Minister of State is a nuclear scientist; the Permanent Secretary and Director of Education is an engineer; the Directors of all the Divisions are science graduates or engineers; and the Director of the Institute of Education holds a first degree in science.

This, however, has resulted in two negative and unplanned outcomes. The first came to light a few years ago when it was realised that there was difficulty in identifying a suitable person to replace a High Court judge who has to retire.

'The number of lawyers qualified, both intellectually and in other respects for appointment can be counted on the fingers of less than two hands. It is because in the last 20 years, very few students with top points, i.e. three or four distinctions in the 'A' levels, have read law .... Almost all our first-class students have chosen to be engineers and doctors.'

(Lee, quoted in Straits Times, 18 March 1981)

It may be interesting to look further into this question because law is one of the most well-paid professions in Singapore. Yet very few of the top students opted for it.

In an attempt to redress this unequal distribution of 'brain-power' generous scholarships for the humanities and law were offered. At the same time some faculties in the university, such
as the medical faculty, place quotas on the number of top students that will be recruited.

This same effect is beginning to surface again, but in computer science. Every student wants to offer computer studies. But after the experience with science education, the Ministry of Education and the Government is resisting pressures to award too many scholarships for this area of study or to overemphasise this in the school curriculum. It may be true that Singapore will be an information society in the future. But for the majority of the population, the only contact they will have with computers will be as end-users. The only skill required will be the ability to use the keyboards efficiently, and this does not need any formal and extended training.

The second unintended outcome is the common complaint that many of the administrators tend to think only with their heads and not with their hearts. It is often said that these science-biased administrators are also unable to see issues on a macro-level - to see the political and social implications - as clearly as one trained in the humanities. How much of this form of behaviour is determined by the political climate, by the culture of the administrative machinery, or by the training in the universities is anyone's guess. Perhaps such hard-headed approach to the solution of problems is what a newly-developed or developing country needs. If this is so, then this is a very powerful 'hidden science curriculum'.

The essential point here is that if the unspoken purpose of making science compulsory for all students is to select the leaders and the few scientific manpower that will lead in the country's economic development, then this approach must surely be very costly. Could this selection be done through a more cost-effective approach? The second point raised is that it is perhaps necessary to maintain a balanced view of human resource development to avoid the dilemma faced by Singapore. But short of social engineering, how could a Government maintain this balanced spread of 'brain-power'?

3. Appropriate Science for All

The preceding discussion appears that I am suggesting that science be restricted to only the chosen few. This is not true. The point is rather that science education should perhaps be defined differently for different groups of students, and for different countries at different stages of economic development. In other words, if we are able to look at science education dispassionately and from a purely human resource development perspective, then perhaps we could agree that it may be necessary to talk in terms of 'appropriate science for all', appropriate to the economy at the macro-level, and to the individual at the micro-level.
3.1 If one looks at the economic growth of many countries (particularly the NICs) one could roughly see four major stages.

**Stage 1:** Economy dependent upon traditional activities. In many countries this would be agricultural activities. However, in the case of Singapore and Hong Kong, this would be entrepot and commercial activities.

**Stage 2:** Importation of technology. This is often the first step in many country's industrialisation programme, and was, and still is (to a large extent), Singapore's economic policy.

**Stage 3:** Adaptation of foreign technology. Singapore has started on this phase for a few years, and Japan's post-war economic miracle was largely the result of this adaptation.

**Stage 4:** Creation of new technology. This stage is reached only when a country has accumulated sufficient wealth to support the very expensive R & D activities.

3.2 Before attempting to match the type of science education with the stage of economic development, it is perhaps necessary to classify science education itself. For the purpose of this discussion, it may be possible to place science education along a continuum. At one end of the continuum is, what I would call, 'reproductive science'. I use this term to refer to the more definitive scientific knowledge and skills which could be divided into two main components. The first component is concerned with the individual's ability to cope with, and control, his immediate environment. Such knowledge could range from personal hygiene for the less developed societies, to genetic counselling for the more advanced. Under the second component I would include knowledge of the impact of science and technology on Man in general. For example, the proliferation of nuclear weapons vis-a-vis nuclear energy, or the use and abuse of computers.

At the other end of the continuum of science education is, what I would call 'productive science'. In this form of science one would be concerned with the use of existing theories to create new knowledge or technology. Hence, there will be a greater emphasis on problem solving skills and the 'scientific processes'.

At the classroom level, the difference between 'reproductive' and 'productive' science is that the latter would be less definitive and more experimental. The main strategy for the latter would be the so-called 'discovery science'.
A few words may need to be said about 'discovery science'. This approach may be supported by different science educators for different reasons. The first group are the humanists who see this approach as a means whereby children can learn what they want to learn. To them childhood is not a 'pre-adult' stage. Every child is a person in his own right and must be respected as such. On the other hand there are others who see education as the learning of an objective body of knowledge. This body of knowledge must be learned if the child is to grow up and become a useful adult and member of society. To them the 'discovery approach' is a useful technique to make this learning process more efficient. This is how most Singapore teachers interpret the term 'discovery approach'. Between these two camps is a third group who sees this approach as the only way of teaching many of the scientific processes. It is through the 'discovery approach' that a child can learn how to observe, to measure, to design experiments, to hypothesise, etc....

Obviously the third interpretation is what the term 'discovery approach' would mean under 'productive science'.

Therefore, one could see that as science education moves from the 'reproductive' to the 'productive' end of the spectrum, it will become more costly; experimental science requires more facilities and equipment than expository science. Furthermore, the teachers required would also change. 'Productive science' would need teachers who have better knowledge of science concepts because it becomes less definite.

3.3 The next factor to be considered is the student. One has to admit that not all are born equal in all areas of human endeavour. Equal opportunity is sometimes taken to mean equal treatment. If this is so, then the equal treatment may, in fact, be unfair to the less able and result in unequal opportunities. On the other hand, if the education system attempts to cater to the less able then there is the danger that it may use the lowest common denominator as the norm, to accept mediocrity, and to fail to cater to the needs of the more able.

Obviously, the decision on the above issue is dependent on the values of both the individual and the society. But the model that I am proposing assumes that equal opportunity does not mean equal treatment. Students should learn the science most appropriate for his ability.

3.4 Based on this assumption, the pictorial representation of the model is shown in Table 4.1.
The rationale for this model is derived from three factors. The first is the requirement in the teaching of 'productive science' vis-a-vis 'reproductive science'. 'Productive science' requires:

(a) Highly qualified and suitably trained teachers. Economies that are in Stage 1 and 2 usually have education systems that have just experienced, or are still experiencing, rapid expansion. Very often this means that quantity is often more urgent than quality in teacher recruitment and training.

(b) Smaller class sizes. This is again difficult to achieve in education systems that are experiencing rapid growth.

(c) More facilities and equipment. Except in countries which have surplus wealth, such as the oil producing countries, this is often another obstacle for newly developed economies.

The second factor is the needs of the other sectors of the economy. As mentioned earlier, 'productive science' requires more qualified teachers. In Stage 1 or 2 economies, these persons are also needed in the other sectors of the economy. To attract too many of these highly qualified persons to join the education
service (through various incentives or compulsion) may adversely affect the economic growth of the country as a whole.

The third factor is the immediate need of the economy. During the first two or even three stages there is very little (if any) need for persons who can create 'new' technology. Almost everyone is involved in the use of existing technology which are imported from a more advanced economy. However, there is a need to train a small group of persons who are able to lead in the development of the economy, when the time comes. But only a small number is required. There is also the very real danger that if the schools produce too many scientists who want to create new technology and if this is not matched by the ability of the economy to absorb them, then the society may even lose these talents. 'Brain drain' is a phenomenon common to many developing countries. Hence it may be more cost effective to provide the rest of the population with a 'cheaper' form of science which may, at the same time, be more relevant to both the individual as well as the economy.

However, as the economy develops and moves into the third or fourth stage then the need for persons who can adapt existing technology or create new technology becomes greater. The general level of education for the entire population would also have been higher. This implies that the first two factors described earlier would have been more favourable for 'productive science'. The normal distribution curve could now be more negatively skewed.

Critics of this model may argue that the knowledge explosion makes it impossible to learn all there is to learn. Hence cliches such as 'learning how to learn', 'lifelong education', etc. I am not denying that these are important attitudes and skills. But one must also accept that while the entire body of knowledge has increased exponentially in the last decade, the quantity needed and relevant to the average individual remains approximately the same. One must not impose the perceptions of the academics on the masses. Furthermore, science education, particularly experimental science, is not the only way to achieve these desirable attitudes.

4. Conclusions

This paper started by describing the historical development and present status of science education in Singapore. In the description of the past and present syllabuses and teaching strategies, it would seem that the science education in Singapore is of a very traditional and, some would even say, low quality. This judgement will come mainly from idealistic science educators whose criteria may be influenced by the trends in science education in the more developed economies of the West. To a typical
classroom teacher in Singapore whose worth is often judged by the examination results he produces each year, this form of science is far more 'down to earth' than the new 'discovery' or 'pupil-centred' approaches.

But does this mean that science education has made no contribution to the economic miracle of Singapore?

The next section then attempted to look at two possible contributions of science education - as the developer of human resources and as the selector of talent. If the latter is the REAL function, then perhaps a more cost effective instrument could be used instead.

However, it is undeniable that a certain, albeit small, number of scientific manpower is needed for the future development of any economy. For example, Singapore's shift towards higher technology would not be possible if it did not already have a pool of such expertise. But the point raised in the third section is that perhaps there may be a need to talk in terms of 'appropriate science for all'. A possible model for looking at this issue was proposed.

But it must be reiterated here that to adopt a differentiated science curriculum for different groups in the population may be politically explosive. Even in Singapore, where there is a very strong Government and where social engineering is accepted as a way of life, a compromise was deemed necessary. However, if this principle is accepted by more educators (who tend to be more concerned with 'equality' than economists) then it may have a better chance of success.

Finally, it was also implied that perhaps some ex-colonial countries, such as Singapore, have yet to achieve intellectual independence. Very often we tend to continue to use the practices and trends in Britain as criteria for judging the worth of an indigenous science curriculum. One tends to forget that the needs of the two countries, and of the people, are totally different.

But what aspects of science education is culture- or value-free? Is it possible or desirable to categorise scientific knowledge and skills to match a) the stage of economic development of a country; or b) the 'employment group' an individual is most likely to belong to? These are some of the questions I believe need to be examined.
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THE PURSUIT OF SCIENCE AND TECHNOLOGY

MANPOWER IN THE 1980s:

Some Conceptual Problems

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THE PURSUIT OF SCIENCE AND TECHNOLOGY
MANPOWER IN THE 1980s:
Some Conceptual Problems

The proposed council (of higher education) and the Ministry of Education, Science, and Technology will help the country more if they borrow a leaf from such newly industrialised countries as South Korea and Singapore, among others. These countries emphasised on scientific studies right from the beginning of the learning process. Through exposure to science, students learn that the discipline is not as mysterious as they might have been led to believe. This leads to more students opting to follow scientific or technical careers rather than artistic ones. In a world in which technological advances are made almost daily, this gives those countries an advantage over others that pay less attention to scientific studies.

The Ministry of Education, Science and Technology should accept the fact that like building a house, you can't begin teaching science from the top. It has to begin from below at the pre-primary level.1

This editorial, coming on the eve of the 20th anniversary of Kenya's political independence, mentions many of the issues with which we are concerned in this conference, and not least the notion that certain Asian nations have pioneered strategies for the systematic investment in science and technology which have had major consequences for their industrial development. As Kenya is not alone amongst the less industrialised countries in wishing to follow some such science-based development path, it will be useful for this meeting to examine whether any such strategies or models exist, whether they have any implications outside the particular political and economic settings where they were tried, and what some of the individual ingredients of such policies might be. That task is much beyond the scope of this present paper. However, as a step towards organising thinking on this and related questions, it is perhaps useful to sort through some of the sets of material that are beginning to accumulate in this area, and to outline some of the interactions

1Editorial 'Science: Preparing to Join the Club' in Daily Nation, Nairobi, December 9, 1983, p. 6.
that may be necessary in these literatures if they are to play any part in an integrated analysis of science-based development.

Rather early in any such exploration, it becomes clear that in many quarters an advocacy literature in favour of science and technology is rapidly developing. Like the high level manpower literature of the early 1960s, many of the assumptions about 'investing in science and technology' are not examined, and, in particular, little attention is paid to the processes whereby scientifically-educated students are utilised in the economy. Expectations run high about the way that science training can be converted into technological development, but in much writing there is little clarity about processes and mechanisms whereby this might happen. As with the earlier arguments about levels of literacy and 'development' or the impact of high level manpower, rhetoric and intuition carry the day. With this difference. The positions being taken by politicians and Ministries of Education, Science and Technology are at face value even more persuasive than their predecessors. It seems almost as if the whole critique of modernisation theory and of manpower planning over the last 15 years has been forgotten as nations set their sights to join the Science Club. The logic is however particularly compelling to countries that have successfully localised their public services since the end of colonialism but still find themselves technologically and industrially dependent on external economies. The prima facie argument is strengthened moreover by the presence in the 1980s (unlike the 1960s) of a set of countries that appear in some sense to have 'made it' by what is interpreted as the single-minded application of science and technology to their entire society.

Nor is this highly instrumental approach to the manipulation of science and technology reserved for African admirers of the various South East Asian and South Asian experiences; it is also to be found very conspicuously in the current political debate about the role of the universities and industry in Britain. One strand of the government's strategy for higher education in the 1980s is precisely to have an impact on industry's competitiveness by the application of 'new blood' to scientific and technological training.

Even if the political debate about scientific investment seems little more sophisticated than the earlier more general rhetoric about high level manpower investment, there do now exist sub-literatures on different parts of this complex process of human resource application. In combination these should be beginning to make us cautious about loose usage of much of the terminology involved in scientific transformation. In particular they are requiring much greater clarity in the use of terms like indigenous technological capacity, scientific and technical manpower, degrees of skill and semiskill, scientific creativity, adaptation and dependency, technological training, transfer, and choice. The
thrust of these various analyses would suggest the following directions:

From a preoccupation with numbers of scientists and technologists to a concern about patterns of their utilisation;

From discrete education planning and science-and-technology planning to a view of their necessary integration;

From a one-world view of science and technology to an understanding of different science and technology environments.

In approaching these and other research and policy questions, there has, until recently, been a tendency for educational and S & T Planning to be concerned with two quite different universes. The former had been almost exclusively concerned with in-school matters - student numbers, school location, curriculum reform, teacher requirements and many other issues. Science and technology planning by contrast was concentrated on the need to formulate a technology policy, develop policy instruments, and consider advice to government on large scale, intermediate and small scale technology sectors. Twenty years ago the then new discipline of educational planning was rather more concerned with the world outside school, and via the manpower-planning enthusiasm of that era participated in the hope that the production of high level manpower could directly influence the economic development of a nation. With the retreat from the more naive versions of investment in education for development, educational planning retreated also into school-based matters until the arrival of this new optimism about investing in science and technology. Unlike the rallying cries of the first development decade, 'Higher Education for Development', 'Education for Modernity', 'Education, Manpower and Economic Growth', the current calls for investment in scientific and technological capacity sound much more directed. Not just higher education, but very specific forms of exposure to scientific and technological training. It may be useful accordingly to examine some of the assumptions that lie behind the policy declarations on science for development, coming from a selected number of documents and agencies.

a) The role of science and technology education in national development

Typical of this new and more specific form of the old coupling of education and national development is the report from the Unesco-sponsored International Development (December 1981). This congress in turn derived from the interest surrounding the U.N. Conference on Science and Technology for Development, and can be seen as an attempt to make more explicit the human resource implications of that wider U.N. agenda.
What is interesting about the Congress report is the strength of feeling about the potential of science and technology. A direct correlation is asserted between a high rate of scientific and technological growth and economic growth. Interestingly enough it is admitted that 'the significance of education in the development process is not so clear' (para 10). Nevertheless, there is much more certainty about science and technology education. 'The conception of science and technology education for national development ... conveys a lot of optimism and hope.' It turns out that science and technology education can directly contribute to a country's primary health and nutritional care, as well as to the U.N. rights to be free from want and to exploit natural resources in appropriate ways. Beyond this, science and technology education can apparently help to ensure more effective control of population growth rates, and can play 'a vital role in solving the most urgent problems confronting the world'. Science and technology education have the ability to help utilise to the full society's human resources in agricultural and industrial activity.

According to the Unesco document, the progressive incorporation of science and technology into every part of the life of societies, through formal and nonformal education is one of obvious ways of producing the above and many other developments. Science and technology education seems to have a comparative advantage in producing that degree of rational thought required for the transformation of society; the list of attitudinal and cognitive changes expected is rather extensive:

Such information should also make it possible to provide young people with the kind of values and attitudes and the powers of rational thought, expression and behaviour that fostered the development of both and individual personality and of an intellect that could adapt itself to a rapidly changing environment and find the right answers to the unpredictable challenges the future may bring.²

The picture that emerges from the Report is of the indispensability of science at all levels of school and society, informing policy makers, teaching the art of intelligent decision making, helping the ordinary citizen to organise his or her own concepts and attitudes. To cap it all, science and technology education, it is claimed, should also be 'considered as an important element of preparing society for individual happiness and collective peace'.³

³Ibid., p. 9.
There seem to be very few hesitations about the positive impact that comprehensive science and technology education can have on developing societies. Science education for all, both in formal schools and in science popularisation campaigns, is portrayed in such favourable terms that it would be difficult to vote against its adoption. There are, however, just a few notes of caution that are entered in the course of the document. One relates to the question of promoting endogenous science and technology, and the second to the possibility that science and technology education may not automatically lead to the rational use of resources.

The issue of endogenous development of science and technology implies that science and technology has somehow to reconcile the importation and application of new technologies with the selection and modification of existing, traditional technologies. But there seems to be something of a contradiction at the heart of this strategy. On the one hand a main reasons for the backwardness of developing countries in agriculture and industry is allegedly "the lack of scientific attitudes in the public at large". At the same time it is recognised that all countries have over the years developed "a store of knowledge, skills and experiences which have enabled them to survive by harnessing certain aspects of their environment".

Rather than abandoning all such traditional lore in favour of imported modern technologies, "efforts should be made to identify any scientific roots in these traditional practices and to base future development on them". What is really being admitted is that there are both "scientific" and "non-scientific" beliefs in traditional peasant communities (or by extension in developing countries). The latter are clearly a major obstacle to the advance of western science-based modernisation strategies. The former may in some sense be allies.

This perspective immensely complicates any genuine attempt at science popularisation, and the role of the formal school in any such campaigns. Acknowledging that indigenous technical knowledge is both "scientific" and "non-scientific" means that the school has the rather delicate task of sorting out appropriate from inappropriate technologies, and "good" traditional lore from "bad". Furthermore, although schools are encouraged to conserve and transfer these elements of "good" traditional lore, it is clear that even with these Unesco believes there will be a need to encourage a new more creative, questioning approach. This suggests that behind the apparent encouragement of some elements of traditional knowledge systems lies an assumption that even the good will need

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5 Ibid., pp. 4-5.
to be subjected to an invigorating dose of western criticism and creativity. In other words, some of the endogenous beliefs may correspond to western scientific beliefs but the attitude towards them of the people who hold them continues to be insufficiently scientific. The lip-service towards indigenous knowledge systems is neatly captured in this paragraph:

The school should serve as a vehicle for the transfer of such traditional technologies with emphasis on the continuity of the society and its accumulated knowledge, skills and experiences. The teaching of this traditional and cultural heritage, however, must encourage a sense of scientific/technological creativity in relation to the local environment. Efforts need to be exerted to convince teachers of the great importance of encouraging creativity among pupils at all levels.6

The attempt to maintain a balance in the Unesco prescriptions between a very eclectic approach to traditional culture and belief systems on the one hand and a strong encouragement to spread western science and technology is not very successful. The axiom 'science for all' is implicit in much of the argumentation, but it is clear from the context that it is major injections of western science and technology that are referred to in this message. Indeed, there is talk of the need for the living local traditions even in the poorer communities to be opened to this 'effective scientific knowledge and techniques for solving their present problems', with the hope that there might be through this a qualitative leap forward to narrow the gap between the industrialised and poorer countries. The document proceeds to underline the part that could be played by computer science and information technology 'to improve national capacities for the management of development, and by biotechnology to meet the basic needs of the population in nutrition and health'.7

If there is very little analysis in the document of the complex interactions between local knowledge systems and western science, there is even less appreciation of these aspects of the impact of western science and technology that have been so widely criticised both in the West and in developing countries. Only in two short paragraphs in the whole report is it admitted that science and technology education might have effects other than those outlined at some length above, and even then there is very little exemplification of the possibly non-constructive role of science and technology:

Science and technology are not a panacea for solving all the problems confronting humanity today. If not developed and used with discretion and control, science and technology

6 Emphasis added, ibid., p. 5.
7 Ibid., p. 6.
can prove counter-productive and may even run contrary to the above mentioned larger goals of realising human rights and satisfying basic human needs. Some negative effects have been felt during the last few decades.  

There is little or no commentary on this bald last sentence or two beyond some reference to ways in which science scores are abused to stream children in school or turn girls against science from an early stage. There is certainly no comment on the supposed neutrality of science and technology, nor on the rather large literature on social responsibility in the sciences. In a word, the paradigm presented by this influential Unesco document is of a basically benign campaign to broadcast widely through the Third World modernisation via the sciences. There is some lip service to local knowledge, but it is apparent that this lacks the critical, creative characteristics associated with the western scientific enterprise. Although the UNESCO document is principally concerned with promoting science and technology for all, via formal and nonformal education channels, it has little to say about the way all this scientifically trained and educated manpower will be used. The preoccupation is more with the adjustment of science curricula in school and university than with the utilisation of educated scientists and technologists. Paradoxically, the Unesco Congress was intended very deliberately to put an education dimension on to the earlier U.N. Conference on Science and Technology for Development, but there is little help for educational planners or science and technology planners concerned with translating educated scientists into policies for development of science and technology in the economy at large. 

b) Planning Education and Training in Dependent Political Economies

We have noted that the Unesco report argues for more science and technology education within what may be loosely termed a modernisation-via-science perspective. There is virtually no reference at all to the process whereby 'Northern' science and technology is transferred to Third World countries, nor any comment on the terms and conditions on which the Third World learns from the North. There is no suggestion of possible conflict between the interests and priorities of industrialised and industrialising countries. Other questions which are not addressed are: the impact of high technology education in countries with a fragile industrial base; the extent to which it is possible to overinvest in science and technology education; the possibility of educated unemployment or under-utilisation of highly educated or trained scientists; the match between the science and technology curricula of the North and the South. However, these and many more are precisely the issues that must be discussed in any integrated

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8 Ibid., p. 5.

9 See for instance the literature associated with the Science in a Social Context Project - SISCON.
attempt to plan science, technology and education.\(^\text{10}\)

So far there has been little attempt in the planning literature on science, technology or education to examine their interactions in a North-South context. One move, however, towards such a perspective is contained in a discussion document by the International Institute for Education Planning (IIEP) in Paris. In this the theme of 'Educational Planning and Technological Development' is selected as one of the main thrusts of the Institute's research attention over their next plan period.

It is immediately clear that the treatment of the North-South relationship and the Education-Technology relationship is very different from the UNESCO document.

First it is assumed that education planning cannot satisfactorily be undertaken without analysing technical change, whether external or internal, and its impact on training needs and qualifications. The tendency to plan education as if it was an autonomous sector and to ignore this perspective on technological change and technical capacity is one reason, the Report alleges, that African countries remain so dependent on expatriate technical expertise. Clearly also, blanket prescriptions of science and technology education for all are the very opposite of this IIEP approach, for without a sense of the direction of technical change, a developing country will be expanding its science and technology capacity in the dark:

Increasing the number of skilled workers, specialists and technical managers without regard to the changing demands of (often imported) technology leads to still further shortages of certain types of qualifications and to a surplus of others, higher education included.\(^\text{11}\)

Second, since technical change is principally located at the moment in Northern industrialised economies, educational planning in the South must as far as possible be aware of the nature and implications of this technological dependency. The dependence of the South on the North, and of the education sector on the wider economy is set out very starkly as follows:

If educational objectives cannot be defined independently of technological change, and if the latter is mainly of external origin, educational planning in the Third World must plainly give proper

\(^{10}\)For an elaboration see K. King, 'Science, technology and education in the development of indigenous technological capability' in K. King and M. Fransman, Technological Capability in Developing Countries (Macmillan, London, 1984).

regard to the worldwide conditions of production and movement of techniques. These conditions set limits to its effectiveness.\textsuperscript{12}

In stark contrast to the UNESCO document which presented science and technology education for all as a readily available commodity which most developing countries could acquire and distribute very widely the IIEP analysis is extremely concerned with the source and conditionality of science and technology education and training. So far from being a good whose supply can be turned on and off like water, the source of science and technology education and training is already highly influenced (if not contaminated) by patterns of technical change and its associated education and training in the industrialised countries. It is argued that the intimate connection between scientific and technological development in these countries and the increasing specialisation in civil and military design and production have led to a situation where the majority of countries are now excluded from the production of new technical and scientific knowledge. 'The most advanced among them (Third World countries) at best produce equipment for the consumer and intermediate goods industry, and in any case their R and D capabilities are far too inadequate and rarely directed to their own needs.'\textsuperscript{13}

With the increasing speed of technical change in the North, and the concurrent internationalisation of its products in developing countries, the world of scientific and technical development has become rapidly polarised. The qualifications required in the Northern science and technology environments will continue to emphasise integrated design and development capacities, whereas the constant importation of increasingly specialised machinery and knowledge in the South will emphasise compartmentalised capacities, restricted to the utilisation of products rather than aimed at their production. The kernel of the IIEP analysis is the contrast between these independent creative and producer capacities in the North and the dependent user skills in the South:

Generally speaking, the qualifications and skills required to use external technology cannot lead to the capacity to reproduce and adapt this technology, and a fortiori, to the capacity to innovate in response to the host country's needs and resources.\textsuperscript{14}

Although the contrast between user and producer knowledge, and as a corollary between passive and active scientific research environments may appear overdrawn, it does fit in with some thinking in India on the creativity of the science community.

\textsuperscript{12}Ibid., p. 9.
\textsuperscript{13}Ibid., p. 11.
\textsuperscript{14}Ibid., pp. 15-16.
It has been argued that the free availability of foreign technology through collaborations has a very direct impact on the nature and utilisation of Indian scientific and technological qualifications. Creativity in the scientific community cannot be combined with an ideology of wholesale foreign collaboration. So, states Dinesh Mohan, 'the industry's foreign collaborations end up influencing what happens in our academic institutions'.

The solution to this technological and cultural dependence of so many Third World countries must come from a deliberate attempt to develop local technical creativity, argues the IIEP proposal. In this task, again, education planning is inseparable from industrial and technological planning, but, providing the state can decide on a coherent policy of indigenous technological development — e.g. the manufacture of strategic, multi-purpose capital goods, then education can begin to have a much more autonomous role: 'Education should contribute to the development of the ability to select and apply techniques, to design machinery and to produce technical and scientific knowledge'.

This approach to indigenous technological development must inevitably be selective since there can be no question of reproducing the production system or the research and development system of the industrialised countries. Acknowledging this is perhaps the most politically difficult part of the strategy. Compared with widespread access to dependent foreign collaboration, it may seem politically unacceptable to argue for self-reliant design and development in only a small sector of the economy. Interestingly, this issue of selection is precisely that which Dinesh Mohan has fixed on as an essential starting point for 'retooling' India's dependent industrial economy:

We must decide which goods are essential for a vast majority of our people and concentrate on manufacturing them without foreign help. We can choose a few critical items where we may still need some foreign collaboration for the short run. But even in these the onus should be on the manufacturer to demonstrate the technology is beyond our present capabilities .... We must (also) aim to produce a few manufactured goods with a high science and research content which must be considered the best in the world.

In both Mohan and the IIEP document there is something of a tension between a basic needs approach to the capital goods sector, with self-reliant design and production of items feeding into mass markets, and the desire to encourage some basic research in new technologies which could rapidly lead to the establishment

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16 Ibid., p. 5.
of some comparative advantage by such Third World countries. 'Fields such as energy, biotechnology and computer sciences could provide opportunities for Third World scientific and technical research to achieve decisive results fairly rapidly.' These latter fields are particularly attractive since they offer apparently an opportunity to move rather rapidly from educational investment to industrial application without massive infrastructural developments.

The role of educational planning of science and technology manpower is clearly going to be very different in the IIEP and the UNESCO paradigms. In the latter, science-for-all perspective, the emphasis is on quantity, bringing the good news of science (from the West) to all men, lightening the darkness of peasant myth and suspicion, and converting men to see that science, like the holy spirit, is omnipresent and all powerful. In the words of one of the more recent characterisations of popular science in India:

Science is all around you and everywhere. The methods of science allow you to understand, make observations on, question and alter your immediate environment (that is technology) to your advantage.18

The manpower implications are almost by definition somewhat vague, when so many categories of person in rural and urban areas are required to adopt a scientific approach. Nor is there any particular concern about the North-South flow of science and technology, or the extent to which local creativity can emerge from dependent science and technology environment. The IIEP framework, by contrast, possibly overdraws the technical and cultural dependence of the Third World, but is properly clear that the promotion of science and technology capacity in the South is inseparable from a critical analysis of the direction of science and technology in the industrial heartlands of the OECD countries.

c) Structural Problems in Technological Self-reliance

It may be useful to carry further the exploration of the key ingredients of technological self-reliance by examining the situation in a very different political economy, where scientific and technical capacities are in very short supply, and where there is no thought of satellites, nuclear technology, or the production of silicon chips. Yet in Tanzania, it is possible to examine some of these same essential themes: technological dependency, the science and technology environment, creativity, comparative

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advantage, and the role of peasant knowledge in relation to science. A joint UNIDO-Tanzania Government document is frankly sympathetic towards Tanzania's declared goals of socialist transformation, but outlines many of the structural obstacles in its way. It thus provides a useful overview of these related issues.

One of the first necessary clarifications made by this document is the difference in kind between the science and technology systems of the North and the South, and the consequent lack of a similar rationale for teaching science and technology in the developing countries:

Let us here point to the fundamental differences in the science and technology systems in industrialised and developing countries. Those in the industrialised world are characterised by the fact that the evolution of scientific activity has led directly to, or is clearly linked with, advances in production techniques, whereas those in the developing world generally are not. Industrialised countries can thus be described as possessing an endogenous scientific and technological base, and developing countries as having an exogenous technological base.

The relation between the science and technology experience in education and that in industry soon becomes rather close. If there are few if any positions for design and development work in industry or agriculture this is soon reflected in the hidden curriculum of education, whatever the similarity of syllabus between Europe and Africa. Even if the school and university promote science-for-creativity, following American or U.K. models, the lack of an organic linkage between knowledge generation and production will lead to the science course becoming a credential rather than a foretaste of basic research or technical application. The bureaucratisation of science and engineering graduates soon has a backwash effect on the education system itself.

The UNIDO report also follows the IIEP in seeing the skills and training needs as intimately bound up with the imported technology. Too often educators and trainers think of skills almost as disembodied, to be promoted (like science) for the rapid transformation of society. Instead, it is clear that a significant part of Third World skill training is related to the maintenance of

20 Ibid., p. 85.
21 Mohan comments on the same phenomenon in India where he alleges 'there are very few challenging technical or scientific jobs offered by Indian industry, op. cit., p. 4.
imported technology. It is particularly true of skills that are institutionalised in national centres and polytechnics, but it is also true of project related training, where, as part of the total foreign project, those skills essential to the maintenance of the plant are delivered as part of the agreement. There is not unnaturally a tendency for such skills to be highly fragmented, site-specific. It must of course be remarked that the fragmentation of skill has been dramatic in the industrialised world, and in this respect there is an important difference between science and skilled work within the OECD countries. Both have become more specialised, but science has gained status with specialisation while skilled labour has lost status by the same process of specialisation and fragmentation. Because of the slower pace of industrialisation in developing countries, accordingly, there has been less deskilling of traditional skill categories. And even in the capital and intermediate goods sectors in developing countries, it is likely that the much slower pace of automation has left intact many of the shaping, fitting and turning skills that have been eroded in the West by new generations of numerically controlled machine tools.

Apart from commenting on the North-South differences in the science and technology environments, the UNIDO report provides some valuable counterpoint to the UNESCO and IIEP reports in the matters of technological creativity and endogenous technology. We noted that insofar as the UNESCO report dealt with innovation or creativity, it saw them as the accompaniment of the spread of scientific temper for all. The IIEP document doubted their emergence in any highly import-dependent regime, where technical change was always linked to new foreign collaborations or direct foreign investment. It argued that creativity almost needed to be protected by policies of selective indigenous development of technology. The UNIDO report on Tanzania goes a stage further and situates the issue of technological innovation within the larger capacity of the society to innovate. Thus, scientific or technological creativity is unlikely to emerge from merely putting into place appropriate technology institutions, capital, and know-how. Even linking organically the capacity for science and technology with productive and educational systems may not be enough; or introducing the appropriate fiscal and trade policy regimes. The social and cultural milieu outside the boundaries of the science and technology elite will be critical. This emphasis on mobilising society takes us back by a different route to the 'science for all' approach, with this distinction, that there is a strong assumption about peasant creativity on which wider policies of innovation can be built. Dissemination strategies will obviously differ depending on whether it is assumed that peasants need science brought to them from outside as opposed to a conviction that some significant resources of knowledge and technology already exist:

(A society's capacity to innovate) requires mobilisation of the creative energies and problem-solving capacities of a nation's population. It requires conscious policies
designed to trace the survival knowledge and technologies 'hidden' in local communities, among the peasantry and in the experience of women. The development of a real capacity for innovation thus requires not only the mobilisation of the technology system but also the social system. Attitudes and motivation throughout society will determine the climate for innovation.22

In this connection it is useful in passing to note that in Korea, Hyung-Sup Choi has argued that it was not alleged unscientific peasant mentalities but infrastructural and communication problems that had to be addressed in creating a national science and technology climate:  

Contrary to the widely held view that a change in rural values and attitudes is a necessary precondition if there is to be a self-sustained change in rural economic behaviour, there have been studies which support a different view. Government efforts have placed, according to its assertion, less emphasis on farmers' psychological motivations and more on furnishing essential assistance to agriculture in terms of credit and technical advice and by providing linkages between the villages and the national economy.23

If it is accepted that technological innovativeness in a nation's urban factories and research labs is ultimately unlikely to be dissociable from a wider climate of change and infrastructural development in the rural areas, then this does raise some serious research and policy questions for countries pursuing strategies of 'indigenous technological capability' without corresponding change in the rural-urban imbalances of income, opportunity and infrastructure. Is it for example the case, as the UNIDO report would argue, that 'it would seem reasonable to conclude that it will prove impossible for all developing countries to effectively embark on their technological transformation without a corresponding social and political transformation?'24

Or are the examples where technological innovation has taken place on a very small base of scientific and technical literacy? These and other questions about the limits of technological innovation and self-reliance are very germane to the many small action groups and science centres concentrating on rural development without any expectation of their efforts being reinforced by any wider incentives to change. Indeed, one of the problems about separating technical from social and political 

22UNIDO, op.cit., p. 94, emphasis added.
change in the countryside is that in some countries the most conspicuous examples of new technologies or dramatic technical change have been those associated with direct threats to the continuance of peasant communities and their autonomy. In many cases, it sounds as if discussion about the value of science campaigns for rural areas assumes that peasants have had little contact with the transforming power of applied science. Quite the opposite is often the case; peasant producers have frequently witnessed the application of new technologies within existing rural power relations, in new high yield crops, new systems of forest or mineral extraction and other areas. Over against some of these alliances between new technologies and political elites in rural areas, the rhetoric of science for all or the search for technologies hidden in rural communities start at a great disadvantage.

d) Issues in the analysis and utilisation of scientific and technological manpower

There has until recently been something of lack of interest in manpower planning, following the spate of national manpower plans of the 1960s and the subsequent disillusionment with their value as a tool for economic and educational planning. In the last year or two, however, some new questions and approaches have begun to be mentioned in connection with manpower, and particularly in relation to scientific and technological manpower. One reason for the relative lack of recent manpower plans has been the absence of newly independent countries in the last fifteen years, and another has been the disenchantment amongst many international agencies with the whole emphasis on high level manpower. With the independence of Zimbabwe, nevertheless, the occasion was taken to organise a national manpower survey, and it is interesting to note the extent to which that survey has sought to look with fresh eyes at many of the most basic manpower and labour market issues. Several of these are of direct relevance to countries at very different stages of industrialisation and development.

The first and most basic assumption of the Zimbabwe National Manpower Survey is that such a survey cannot avoid being both a technical and a political exercise. This is worth stressing, particularly on the science and technology side, since many of worker categories (scientist, engineer, skilled man, technician, etc.) sound as if they have an international currency and would not change significantly from country to country. The fact is that most of these categories are in some sense socially and politically constructed, and in the case of pre-independence Rhodesia, affected by white settler ideology and racial politics. The Report is able to show convincingly that the category 'semi-skilled', for example, is racially determined to include large numbers of blacks who were technically-speaking skilled, but who had to be distinguished from direct competition with white artisans. At the other end of the scale, the Report argues that the almost inevitable reaction at independence to these racially-constructed categories (and corresponding salary scales)
is to Africanise the white jobs without questioning the assumptions that underly the enormous differentials. This is of course a question that almost all ex-colonial countries have had to face, and, in incorporating the colonial manpower disparities directly into the salary structures of the independent state, have often from the outset placed many scientific and technical jobs at a salary and status disadvantage compared with jobs in the administrative service. The Report comments:

But the emphasis on the race question should not lead us into ignoring the fact that Africanisation alone does not essentially alter these relations of production. The pattern of employment and the salary and wage structure remain largely intact even though many Africans now occupy these high salaried positions. For example in the public service the ratio between the highest paid (the Permanent Secretary) and the lowest paid (the messenger) is 1:75. It is unfortunate perhaps that in seeking to remedy the manpower situation our main concern has been to ensure that Africans reach parity with whites in this employment and salary structure.25

These two examples from Zimbabwe have their counterparts in most other nations, in the sense that the local usage of apparently standard international job descriptions (such as 'technician' or 'technologist') varies enormously and usually reflects a compromise between an older local tradition about skill and knowledge, and a newer imported set of international categories, reinforced by educational and professional qualifications. The tension between the local traditions about skill and technology and the formal diploma and degree-based categories is at the heart of many of the difficulties of analysing or investing in scientific and technical manpower. But this is not just a contrast between the informally trained, on-the-job experienced technician or engineer and those formally trained in polytechnics and engineering colleges, although the substitutability of the one for the other makes it extra-ordinarily difficult to plot their separate contributions to a particular industry. (Thus, the existence of large numbers of 'engineering practicals' in Indian manufacturing industry (highly skilled and responsible maintenance and production supervisors with little or no formal technical qualification) makes it difficult to assess the industrial demand for formally educated engineering personnel.) There is also a contrast between the formal qualification system as it operated in the original country of export (Britain, France, or U.S.A. for example), and the local set of negotiations about the acquisition of formal qualifications in the ex-colonial country importing these categories and labels.

That is to say that local traditions about skill and knowledge are visible not only in the informal systems of skill acquisition, but also in the heart of the formal education system itself. These local traditions are more accurately to be defined as complex negotiated agreements and assumptions about the way technical (and other) manpower is produced and utilised, and in what quantities. As such it is a highly political construct agreed to by industry, and the state's training ministries. Thus the number of formally registered apprentices in Zimbabwe, Kenya and India, for instance, reflects both a tradition about skill acquisition in these different environments, and also a negotiation between industry and the state about what proportion of the particular country's skilled manpower should be exposed to this apparently western training system. But these local political negotiations invariably alter the meaning of apprenticeship, so that shortly after the apprenticeship mode is imported (via ILO, external or national funding), its shape and operation is indigenised.

Any serious attempt therefore at analysing (let alone projecting) national manpower has to sort out the ways in which local traditions of skill (which are themselves by no means static) interact with indigenised formal education and training qualifications. This implies not so much a calculation of how many apprentices, technicians and scientists there are, but rather why and how these various skill and knowledge categories are used in different kinds of industries and public enterprises. It is likely, for instance, that there are a series of different mixes of engineering qualification in Indian manufacturing industry, reflecting India-specific use of 'engineering practicals', diploma holders, and graduate engineers. These mixes in turn affect college and polytechnic engineering enrolments, and are themselves affected by decisions on engineering enrolments in the education system. Thus, a national policy of close control on the expansion of engineering education at the degree level will itself influence the way in which graduate engineers are used by industry, commerce and the public sector, as will a policy of allowing engineering colleges to expand in response to market forces.26

A qualitative analysis of various types of scientific and technical work which looked at the dynamic interplay of local knowledge acquisition systems with the more formalised official qualifications would itself help to answer a number of the larger questions about innovation and technological capability which have been mentioned earlier in this paper. The following suggest themselves as areas of research that could emerge from such a focus on the utilisation of scientific and technical manpower:

26 India provides an interesting case study of the federal control and subsequent opening of engineering education to popular (and political) pressure at the state level, especially in Karnataka and Maharashtra.
1. The IIEP assumption about different skills associated with using imported technology as opposed to innovative skills linked to local technological production could itself be tested through case studies of technical skill and engineering in essentially foreign collaborations and in more autonomous technological enterprises. It seems highly likely that the skill mix associated with the particular technology in the country of origin is altered very significantly in the receiving country, but that the resulting skill and knowledge requirements reflect much more than the mere user skills needed to run machinery designed elsewhere. The final skill mix in the importing country will also incorporate that wider set of economic and political negotiations about training and work to which we have referred. These local negotiations will often result in engineers or technicians being used on the factory floor where the demands of the technology alone do not actually require them. Their presence is not then a straight forward result of technological determinism.

2. Researching the local mix of skills and engineering knowledge on the factory floor can also offer insights into questions of innovativeness, creativity and technical change with which we have been concerned. For example, it might be suggested that industries relying heavily on engineering 'practicals' might be less prone to technological change than industries with a heavy concentration of science-based graduates of polytechnic and college. It might further be explored whether the substitution of science-based manpower for hands-on experience (which is going apace in Indian industry) may be associated with any increase in product quality. Alternatively, if larger numbers of science and technology diplomates and graduates find themselves replacing 'practicals' and working in positions that only require a fraction of their science-based knowledge, this will not necessarily lead to any consciousness of product quality, especially if the enterprise as a whole has little interest in research and development.

3. In the wider debates about the impact of science and technology policies upon indigenous technological capability, case studies of particular industries and their science manpower may be valuable. What are the precise consequences of the collaborationist mode with foreign technology on the one hand and the protectionist mode on the other as far as skill and knowledge at the firm level are concerned? We have already referred to Mohan's view that the dominance of foreign collaborations directly affects the production and utilisation of scientists in India.

But over against this, just as provocatively argued, is the view of Sanjay Lall that the protectionist technology policy regime in India has certainly not had the effect of stimulating
a dynamic or competitive indigenous technological capability.\textsuperscript{27} It would seem that neither India's forms of foreign collaboration nor of industrial protection have acted as catalysts for innovative R & D, nor have promoted powerful backwash effects on the quality of science. But again, it looks as if rigorous research on the impact of different trade policy regimes on the science and technology environments has scarcely been done.

3) Science manpower for new technologies: Science cities and science villages

A final area that may be worth flagging relates to the manpower side of new technologies. This seems to be an area where there is considerable confusion, and where very little social science research has been addressed to the choices and decisions facing developing and industrialising countries. The lure of the new technologies (genetic engineering, biotechnology, microelectronic applications, for example) raises in a new and urgent form many of the issues that have been discussed earlier, not least the question of indigenous knowledge, selectivity, comparative advantage, and relevance to the mass of people living in rural areas.

There is however something of a tension between the science-for-all perspective associated with the more traditional science popularisations campaigns of many countries and the new-technologies-for-all message that is becoming increasingly commonplace. In the former, it is expected that science-based messages about health, agriculture, family size, etc. will be able to displace so called 'unscientific attitudes', and gradually transform village life. The outcome might be termed a 'low level scientific temper', improving yields gradually, reducing family size as family income grows. At the same time however what may be called 'high technology scientific temper' (or tempter?) suggests that these same goals can be achieved and the quality of life and work much more fundamentally and rapidly transformed by introduction of newer new technologies.

Some of the literature on the importance of these new technologies in relation to developing countries shares the rhetoric about leapfrogging the slower agricultural and industrial revolutions of Europe which was so commonplace in the 1960s; but they often go beyond even that optimism to expect qualitatively different experiences for communities exposed to new information and other technologies. The extreme form of this transformationist thinking can be seen in the current experiment to saturate with French microcomputers a simple village in Senegal to see if some cognitive leapfrogging will result. But there are plenty of

\textsuperscript{27}Sanjaya Lall, 'India's technological capacity: effects of trade, industrial and science and technology policies', in K. King and M. Fransman, op.cit., pp. 238-241.
illustrations in other countries where the allure of new technologies beckons to the science and technology planner, and even to the education planner. Thus, educational technology which had emerged from the 1960s and 1970s battered if not defeated by the signal failures of educational TV in the Ivory Coast, Niger and elsewhere, enters the 1980s with the bright new armour of computer literacy, VCRs, computer conferencing for schools and much more. These are marketed not any longer as educational aids or extras, but as instruments that will dramatically change the cognitive experience of children. When ministries of education in developing countries hear tell of the hoped-for qualitative changes in the child-power of OECD countries, it must be extraordinarily hard not to order up the same machinery. Typical of the new information technology literature on the impact on schools is the following:

unprecedented changes could indeed take place affecting the following sectors:

(i) Learning processes could be changed and school children much earlier acquire certain logical structures and formal and conceptual skills currently developed only at later school ages. It is also likely that they would learn different skills and build different knowledge systems in ways which we are only beginning to perceive.

(ii) Curricula could be radically remodelled.

(iii) The individualisation of education offered by interactive NIT* could turn over the very structures of the institutions concerned.28

Nor is NIT seen in the OECD context as an occasional 'micro' in a secondary school, but as a highly complex interactive learning style with some or all of the following components:

The New Information Technology ... are computers, videotex, cables and fibre optics and satellites and computers in conjunction with traditional or new audio-visual technologies. There is already a tendency towards interactive multi-media systems combining sound and picture, all under computer and particularly micro-computer control.29

This is heady stuff for educationists, in what has always been regarded as one of the most labour-intensive service sectors.


29Ibid.

*New Information Technologies
But in other sectors and ministeries, equally compelling applications of microelectronics and other technologies make it hard to be selective. The new information technology order appears like a seamless web; it must be bought as a package or not at all. Also unlike the engineering technologies of yesteryear, there is a distinct sense that tomorrow may be too late to join a race where ten years covers more ground than a hundred in the older technologies.

At the international level, the United Nations Advisory Committee on Science and Technology for Development have been arguing for the integration of these new technologies with traditional technologies. Again, the logic of transforming traditional technologies with new applications is compelling. Over against the thirty or forty years of promoting gradual change through appropriate technologies, the new disciplines beckon with offers to increase productivity, transform quality, and somehow catapult the idiosyncrasy of artisanal products into world markets previously denied them. A document worth examining as representative of this trend is that on Integrated Application of Emerging and Traditional Technologies for Development. The starting point for its discussion is the assumption that 'prospects of technological innovation, particularly in micro-electronics, biotechnology, communications and satellite technologies, are changing life styles and development patterns in developed and developing countries'. In each major sector, examples are held out of ways in which these new information-based sciences are transforming the potential of developing countries.

A very rich example of the vistas that open up in this kind of literature refers to possibilities in agriculture, medicine and biology. Each sentence points to a new disciplinary era, but by the end of the passage, the link to traditional technologies is a little thin:

Some modern technologies have been successfully used to upgrade traditional methodologies. For example, the International Rice Research Institute is successfully utilising various traditional and new technologies, including a large computer system, to accelerate the pace of progress in rice research. Other examples are remote sensing for land and resource assessment, development and application of environmental monitoring and computer use for correlation analysis between crop growth and climatic conditions and crop disease epidemic forecasting.

It is now generally recognised that emerging biotechnological developments in areas such as tissue culture, genetic engineering, and monoclonal antibody techniques are opening

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new horizons for application in different biological fields. Atomic energy and tissue culture are being utilised to speed plant research and develop new crop varieties.31

All the topical areas of new technology are mentioned - remote sensing, environmental monitoring and computer modelling, genetic engineering, biotechnological research, but little is said about the mediation of this new knowledge from those countries which currently possess it to LDC research centres and in turn from LDC centres to the present users of traditional technologies in the villages and towns. There are serious manpower issues to be discussed at both stages of this knowledge production and dissemination in LDCs. Not least there is the problem of getting behind the loose images of applying these new technologies to traditional technologies. Is, for example, the design and development of new technology products to be done in the huge research laboratories of the West and only the finished products to be made available to LDC researchers and farmers, or can an industrialising LDC readily replicate the research culture of these new technology laboratories, with their close links to multinational capital?32

The upgrading of traditional technologies by the application of new scientific knowledge (if not of the newer new technologies), is an area where India has had much experience. Most of them have involved a lengthy dialogue between modern research scientists and villagers, usually in a single village or pilot site. The process has been highly labour intensive and the success in injecting new science-based techniques into traditional technologies has been restricted very often to a single pilot village and to one or two crafts. Whether the village has been associated with an IIT, with ASTRA, NISTADS, or with the dedication of individual scientists who have located in villages, the mix has been similar, the replication a problem. But the spread of low technology scientific temper has always at its best assumed that there could be a profitable dialogue between modern scientist and traditional craftsman.33 By contrast, the newer proposed integration of traditional and new technologies discussed in the development literature of the U.N. and elsewhere will almost by definition have no room for dialogue with the present producers. Although aimed specifically at the small scale informal sector operators in rural and urban areas, the following agenda seems just a little remote from the realities

31Ibid., p. 7, emphasis added.
32For an Indian critique of these possibilities, see Praful Bidwai, 'The seamy side of the Gene business', Times of India, November 21, 1983, p. 8.
33For a very recent example see CSIR S & T Field Station at Bankura (West Bengal) Project: Village Artisans and Science: a Profile, NISTADS, CSIR, New Delhi, 1983.
of petty production in the unorganised sector of the economy:

The Group identified the following emerging technologies as offering scope for integration with traditional technologies: communication, computer, and information technologies including satellite application; micro-electronics in areas such as computer aided design and manufacture and numerically controlled machines (robotics), office automation, etc.; mini-factories with self-monitoring, self-diagnosing microprocessors; new materials, including lasers, polymers, ceramics, new sensors, and optical fibres; and new energy technologies for harnessing, processing, distribution and efficient use of solar, geothermal and biomass power, etc.\(^3\)

Just in case this may give the impression that all will be swept away in the application of new information technology to village life, the report admits that there may still be a place for a few old-style artisans:

> Some traditional manufacturing technologies must be maintained to use local skills. Developing countries may need to preserve traditional industries and artistic production, such as batik and woodcarving, that do not suffer competition from modern technology.\(^3^5\)

We have suggested that in the heady language of computer applications to traditional technologies, the training and manpower issues get neglected, or rather the impression is created that the new technologies somehow incorporate and transform the villager almost without training, as older technologies have never done. In the newspeak of new information technology therefore, the villagers with their village level micros begin accessing world knowledge on specific development problems of their community. Within seconds an interactive dialogue is underway, preferably via satellite, and the 'distinct receiver demand' articulated and answered. The communication process is itself the training. In a remarkable passage in this newspeak of interactive communication the U.N. Advisory Committee discusses what is left of the training dimension in this new information technology order. It deserves quotation at some length:

> Institution builders with capabilities to organise research and development, formulate policy and strategy, and develop and implement projects and programs must be trained. Specialists with specialised knowledge in traditional and emerging technologies who have multidisciplinary competence and social awareness must be taught to lead research and


\(^3^5\)Ibid., p. 9.
development projects. Developers must be organised into mobile productive systems and communicators must be included in projects to build bridges between users and innovators as well as between research workers and policy makers. Technicians, artisans and others must be encouraged to spread the knowledge downstream and bring problems upstream for technology developments. Utilisation of emerging communications technology and software development for this purpose will carry messages to the community.

Developing nations could selectively draw upon expatriate nationals who are working abroad, especially in the areas of emerging and high technologies, to bring about development of integrated technologies and human resources.

Human resources development at the grassroots level and for upstream flow requires a different approach. Normally, the introduction of new techniques and technologies is easiest when preceded by a distinct receiver demand articulation.36

For the social scientist concerned with the interaction of science, development theory and human resource implications, the world of new technology and the related negotiations about the terms on which it enters the traditional domains of the school, the farm, the factory and the office, should be high on the research agenda. In many developing countries, decisions are being taken in relation to information technology for development in every sector from computer literacy in schools to office technology, and even where decisions are not explicitly taken, developments occur by default. There may appear to be a catch 22 aspect to social science analysis of these developments, since it could be argued that until the new technologies are in place, their social impact cannot be evaluated, but once they are in place, it is too late for social scientists to have any influence on the decisions.

In this respect it seems essential for some Third World researchers to be examining the development of the new technologies in the industrial heartlands of the North, in the same way as we have mentioned the necessity of understanding the implications for skill in the South of technical changes in the North. There is fast becoming available critical work on the social and political aspects of new information technology, but this work in the North is submerged by the mass of advocacy writings on NIT. It seems highly appropriate for instance for the groups associated with Science for People in the U.K. and parallel publications in the U.S.A. to be known to social scientists concerned with People's Science in India and elsewhere, and vice versa.37

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36 Ibid., pp. 12-13, emphasis added.
Anil Agarwal of the Centre for Science and Environment has made a similar point about the need for South-North communication if social scientists are to be able readily to monitor and critique developments in their own country, and has underlined forcefully the structural problems in maintaining open access:

An enormous amount of research of relevance to developing countries is taking place in developed countries. For instance, research work on malaria vaccine is not being undertaken in any of the malarious countries ... but in places like Paris, London and New York. The work in the international agricultural research institutes has an enormous impact on national agricultural research systems. But given the fact that information bases in Third World countries are still so under-developed, it is not always possible to talk to someone locally (as a journalist would do in London) about the details of, say, the Brazilian alcohol programme to replace petrol. Travel to a foreign country is inordinately expensive for a Third World journalist, often even 15 times more expensive than his/her counterpart in a developed country.

The same applies just as powerfully if not more so to social scientists, and scientists in the Third World.

Conclusion

We have attempted to suggest in this brief review of selected national and international literature on technology, science manpower and education that there are significant benefits likely to accrue to an interdisciplinary approach to many of the issues in these areas. This is particularly appropriate since so many of the groups, centres, ministries and international bodies proposing science-based action have an explicit or implicit education dimension for their intervention. Equally, the education investment activities whether in computer literacy, quality in science at the college level, or skill acquisition for artisans in the unorganised sector, all make certain assumptions about the utilisation of the science and technology course in society. Frequently these assumptions are not thought through, nor their implications at all clear; on other occasions, as with the apparent planning of engineering or medical places at university, the rationale is as much the result of a political negotiation as a technical or economic calculation.

More generally we have noted that there are several competing advocacy positions involving science and technology, and much debate about relationships between western science and education

38 Anil Agarwal, 'Science in our daily lives', Advisory Committee on Science and Technology for Development, April 1983, mimeo, p. 33.
and local skill and knowledge systems, and in turn between westernised local skill and knowledge on the one hand and indigenised western norms and traditions in science and education on the other. Assumptions about how the modern relates to the traditional, and the newer to the new, are extremely varied, and frequently unexamined. India, however, already has a very rich strain of work relating to the philosophy and sociology of science; this has gone far in sorting out the different science colonialisms and indigeneities, the clashes both within the knowledge systems of the exporters and the recipients, and the dynamic interactions between the sciences of Europe and of India. The historical depth of much of this analysis of sciences in India has been one of its greatest strengths, and is an essential element in counter-balancing much of the international development literature on these themes, whose time horizon is seldom further back than the 1970s. The debates therefore about new information technology and science cities today can be built on a long and distinguished set of concerns about science, technology and education relationships in India.

So, as the Science Congress in West Bengal in 1984 calls amongst much else for investment in quality science through a chain of institutions for the gifted from nursery to college, and for special privileges to be attached to the instructors in this new network, it is valuable on the one hand to have available in India both a science-for-all rationale that is older than UNESCO and a searing critique of the magic of education investment for industrial transformation that precedes the era of manpower planning, and is a useful counterpoint to Kenya's science rhetoric with which this paper started. Prafula Ray, the early Bengali chemist-cum-industrialist writes of the inter-war years:

I had to point out how most absurd and fantastic notions are entertained by our countrymen on the capability of a Technical Institute. Our Universities and Educational Institutions in general impart education which, it is urged, is too much of a literary character; all that you have to do is to substitute technical for literary instruction, and industries will spring up magically all around.

Sir M. Visweswaraya's passionate plea for the creation of a Technological University is based upon this obsession ....

Never was a greater delusion entertained. In every country, industrial progress has preceded progress in science and technology.39

ENGINEERS FOR RURAL WELL-BEING

Farzam Arbab
FUNDAEC was created in 1974 by a group of professors from the Universidad del Valle, the state university located in Cali, Colombia. At the time, there was much discussion about development and the role of education in development, and a great deal of the work that gave impetus to multisectoral, integral development plans in many Latin American countries was being carried out by interdisciplinary groups created in institutes and universities. The FUNDAEC group began by participating in these interdisciplinary activities, but soon decided that they mostly presented efforts to better organize the modern sector, to study and understand the poor, and to offer them improved services. Without wishing to enter into endless discussions on the definitions of development, it seemed that most programs either considered it as a product that was prepared and handed out to a people or as an automatic result of access to political power. The question was how should the product be packaged or who should be on top of the political power structure. But these were basically views of outsiders. For a given population, development surely had to be defined in terms of a very complex set of processes, each of which would include components internal to the population as well as aspects related to the dealings with other peoples. From among these processes, the participation of a people in its own path of development, and the control it had over this path would have to be given a very special position. The concept of participation was of course far different from the usual ideas of feedback, contribution in labor and kind, involvement in the detection of needs and formulation of plans, all of which speak of methods to involve segments of a population in a determined set of programs. Participation, presupposed at least two indispensable factors, a strong and viable community structure, and a well-organized common learning process. How could a people such as a given rural population be in charge of its own development, if it had no access to knowledge so easily available to other sectors, if it did not learn systematically from its own experiences, and if, in general, it did not participate in the generation, as well as the application of knowledge accumulated at a global level?

It was decided then that the first task, in a strategy to bring about change, was the organization of a learning process, and the first institution an education one, understanding education, in very broad terms almost equivalent to development itself. In fact, FUNDAEC was created to be such an institution, to become more than a school or university in the traditional sense, but to involve itself in all the aspects of community life, in an effort to bring
knowledge to bear on the problems of rural development, examining them always from the point of view of the inhabitants of the regions it would wish to serve.

The institution that has resulted from the experience of FUNDAEC during nearly a decade has been called a rural university in order to indicate the level of its capacities, but in fact, the word university with its traditional connotations does not adequately describe the role that is assigned to it. Not only is this rural university concerned with education at all levels, but its role in the development of the region is conceived differently than in most institutions of higher learning. Basically, it considers its main objective to be the search for strategies for the development of the region it is to serve; training programs, the nature of which must necessarily change over time, are only specific components of these overall strategies.

The objectives of the rural university are stated in terms of setting in motion and catalyzing a number of processes within the rural population which in their totality would form a lasting process of development.

Among these, three types of activities are given special importance and great effort is made to carry them out simultaneously.

The first set of processes is concerned with the development of manpower. The corresponding programs cover education at different levels, use formal and non-formal methodologies and their basic concern is the totality of the structure of manpower for the development of the region.

A second series of processes, concerned with the application of knowledge and the adaptation and propagation of technology, are set in motion simultaneously. The rural university dedicates much of its efforts to the gradual development of the scientific and technological capacities of the rural population and carries out research in both the social and technical aspects of technological development.

Yet a third series of processes, with which the rural university is concerned, is related to the organization of the community. Organization, however, is conceived in more complex terms than simple group action and community projects. The whole structure of the community and the region, the services they offer, and the institutions and mechanisms that sustain social and economic activities at the village level are studied. Heavy emphasis is put on production, and channels for the flow of goods and marketing, for access to credit and the accumulation of capital, for the flow of information and technological assistance (without the support of which increases in production and income are not possible) are improved or newly established. Within the context of this component, the rural university's activities in
production become linked to training and research in technology, as these invariably have factors concerned with the various production processes.

It is beyond the scope of this presentation to describe even in general terms the diverse activities of the rural university of FUNDAEC during the past years. It seems best, then, to discuss one of the programs, the first in the process of the development of human resources, which in fact served as the central activity around which many other projects were formulated and carried out.

In 1974, during early deliberations on the nature of the educational aims of the rural university, it became increasingly evident that the skills, instruments and disciplines developed in traditional universities were not directly applicable to the conditions of the rural areas, and addressed the reality of other societies and other historical situations. Careers and professions were not chosen on the basis of an analysis of social needs, but according to the academic traditions of established institutions. It was felt that the natural, all embracing structure of knowledge had been obscured by its division into disciplines each of which had developed its own social concepts and ideology. The biased approach of single disciplines to rural development was clearly counter-productive and superficial, and interdisciplinarity did not seem to constitute a serious alternative.

In general, the founders of FUNDAEC were losing faith in traditional rural training, and in the never ending attempts at curricula reform within the existing structure of disciplines. They began to envision as the first and most central responsibility of the rural university, the establishment of a long term process of search and action through which they would constantly identify related problems and opportunities in the region, would establish the characteristics of the human resources capable of confronting these problems and would design, change, and teach curricula for the development of the necessary manpower. Moreover, problems and opportunities were to be identified in the context of a constant search for new insights into human nature and not in terms of theoretical models of preconceived political systems. The resulting educational programs, then, would not be utilitarian, but would address fundamental intellectual and spiritual issues, not only of a single individual but also of a community.

The first effort along these lines led to a program for the training of individuals at three levels: Promoters, Technicians and Engineers in rural well-being, capable of working directly with rural families and able to coordinate the efforts of different sectors to assure an integrated approach to rural development. However, the activities initiated in 1974 did not involve the first two levels and concentrated on the education of a first group of engineers, who together with their professor,
would later set in motion the different development processes in the villages, including the gradual formation of the pyramid of workers in rural well-being.

By putting the entire emphasis of its initial efforts on the most vulnerable group of youth who invariably leave rural areas in search of better opportunities in the cities, FUNDAEC was departing from the accepted practices of rural development projects. Its basic assumption was that it could design new and innovative educational programs that could help an appreciable percentage of these youth go through a university level training almost independent of previous formal schooling, and thus accelerated enormously the process of the development of human resources in the region.

In May of 1975, twenty-six men and women between the ages of 16 and 23 were selected to enter a six-year program and a smaller group was chosen two years later. By 1980, many of them had proved the validity of the initial strategy and in spite of the fact that some had previously completed only a four year primary education, all had demonstrated an enormous capacity to learn and to translate the new knowledge into action for the benefit of the community. The experience had begun within an atmosphere of skepticism and even ridicule from the educational establishment; it is now considered by the same authorities as a unique and most successful educational experience.

Some of the characteristics of the curriculum developed for the engineering for rural development program should probably be mentioned here. From the very beginning, it was decided to look upon the process of the creation of new content as a series of consecutive approximations in which educational activities would not be defined in terms of narrow and precise objectives as has become so fashionable during recent years.

Years of teaching had shown the FUNDAEC professors how their conventional university students, accustomed to comfortable definitions and well-defined situations, were at a total loss when confronting the complexities of the process of search for new knowledge. It may be said that the FUNDAEC professors were process-minded, and were definitely rebelling against undue emphasis on hypotheses and objectives, which they considered to be the result of a narrow interpretation of the methods of science.

Emphasis on processes was closely related to the decision to structure the new curricula in terms of concepts and capabilities rather than simple skills and information. In fact, the tendency to deal with concepts was overemphasized during the first years and the curriculum was revised to gain a more desirable balance between facts, skills and concepts.

The concepts and capabilities necessary for a new type of generalist worker in rural well-being were finally deemed to fall
into five basic categories: mathematics, sciences, language, crafts and technology, and service to the community. The curriculum was organized then in five blocks or areas accordingly. It is important to emphasize that the categories do not refer to content but to capabilities. Thus, for example, the first unit of the text of mathematics is mostly on taxonomy where concepts related to sets are treated within the context of plant and animal classification.

It is a firm conviction of those who have taught the FUNDAEC curriculum that much of the success in achieving such a highly accelerated learning process in the students is due to the emphasis on in-depth understanding and the development of attitudes and capabilities.

The next set of ideas to be mentioned are related to the methods of imparting the educational message. Educational technology was of course in vogue at the time, yet it seemed to the FUNDAEC group that too much emphasis on form rather than content had led the field of education away from the realities of most people. The textbooks used in the Colombian system had definitely become more colorful during the previous decade. Convenient formulas and conclusions were presented in neatly arranged boxes on the appropriate pages. In schools of education, courses were being taught as how to use audiovisual gadgets, how to program, and how to organize time and space. Above all, everyone was learning to formulate objectives, and strangely enough, the objectives that were being formulated were excellent, and based on the most advanced educational theories. Yet the message, the content of the educational material, continued to be the same. There was no correspondence (and there is still none) between the most impressive objectives that the authorities have set for the education of children and youth, and what is taught in the classrooms everywhere. As far as rural education is concerned, the content is urban, dogmatic, fragmented, rigid and superficial. It dissociates the student from nature and the reality of his surroundings, imparts little social, moral and spiritual teachings and hardly contributes to the development of creativity. No matter how much technology is used in presenting this message, it continues to lead to rote learning, to superficiality and to intellectual boredom. Within this context, it was imperative then, that FUNDAEC should dedicate itself to the search for a new content even if the form would continue to be the most traditional; textbooks, classrooms, teachers, students, chalk and blackboard.

The decision not to introduce many modern educational aids in the program, of course, should not be taken as rejection of educational technology. The FUNDAEC group was not denying the usefulness of technology, it simply asserted that the form should follow the content and should not become an end in itself.
Nor should the above comments be interpreted as a total lack of change in the form of the teaching-learning experience. The search for a valid rural education undoubtedly implied a change in the conception of the relationship of many of the elements of the educational system, time space, students, teachers, school and the community.

Of special interest is the relationship that was established between the students and the professors at FUNDAEC, which is one of co-workers embarked on an enterprise of great importance; the search for the path of development of their people. The student is not considered to be an empty container which is filled drop by drop, but clearly, a mine of hidden talents and potentialities that need to be discovered, perfected and directed towards the service of the community. The method of teaching, reflected in the design of textbooks, is one of raising questions, and trying to find answers in an atmosphere of consultation among the teacher and the students.

But seen as a whole, the most important characteristics of the efforts of FUNDAEC in its first decade of existence have been related to the concept of integration. Within a larger context, the group was clearly trying to add new and important elements to the concept of integrated development; in education too, one of the central issues was integrated curricula, and both aspects of integration were seen to be closely related.

Attempts to create integrated curricula are, of course, not new and the professors who established FUNDAEC were well aware of many efforts which, in general, could be characterized as trying to bring together knowledge pertaining to different but related disciplines and fields of knowledge. One such discipline, an activity or a theme is always chosen as an axis around which a unit of instruction is prepared, usually for pedagogical reasons which, however, are not very clear in themselves. For FUNDAEC, the issues of integration was far more essential than its mere implications for the enhancement of learning; it was to be a key to solving a number of conceptual and practical problems. It was strongly felt that the division of knowledge into disciplines has been given undue importance in a period of human history, marked with technological progress and increasing specialization. Yet, reality, as complex and vast as it may be, is one, even though it allows for the possibility of infinite variation in the ways it can be seen, described, and studied. Consequently, knowledge is also one and its division into disciplines is, in the first instance, nothing more than a result of the finiteness of the human mind which has to choose a limited aspect to deal with. This choice, however, is not a mere consequence of pure human thought and meditation; it is affected most strongly by ideology and social conditions. Thus, the way a western university is organized in departments dealing with defined disciplines is as much a reflection of a style of
life, of a social ideology, and of historical realities of a people, as it is of a convenient division of knowledge to be grasped by individuals of different talents and inclinations. Therefore, when a population establishes within itself an educational system with such a structure, it is buying more than knowledge; it is making definite statements about its future social organization.

In practice, of course, this same structure of specialized training is facing a crisis as it tries to solve the problems of the developing countries.

The frontiers of disciplines, on the other hand, are not entirely fixed in materially advanced societies where modern university models are originating. New problems are constantly formulated which often require the creation of new intellectual disciplines. However, seldom is the movement towards integration and generalization. The tendency, with few exceptions, is towards concentration on narrower and narrower problems and fields. At a philosophical level, one could argue against this tendency and relate it to some of the evils of modern society, but, at the time, FUNDANE was not concerned with such arguments, and was trying to face concrete problems and issues. The curricula taught at the universities in Colombia, mostly direct transplants from universities in other countries, did not prepare individuals who were capable of solving the problem of the small farmers, or for that matter, of any other section of the majority of the population of the country. The graduates of these universities were taught to function within a different society, which was presumably being built through the process of modernization, but to which could belong only a small minority. It was clear, then that new curricula should not be developed from sums of disciplines of professional programs designed for other social realities. The interdisciplinary group was limited when it came to action, and so would be the professional that tried to substitute it by learning parts of each discipline, superficially.

The alternative finally adopted was to give a broader meaning to the concept of integration in curriculum design and define it as a process through which relevant elements from the universe of knowledge would be fused to create programs for the education of individuals with certain desired purpose. Moreover, it was argued that this purpose should not be based on pedagogical considerations only; the integration of a specific curriculum should best be guided by a social purpose: the engineers in rural well-being were educated for the specific purpose of improving the well-being of the communities; the same purpose would have to become the basic guide for curricula integration. The axis around which an integrated curriculum would be built, then, rather than a theme, activity, or a subject matter, would become service to the community. Moreover, service to the community and promoting the development of the region was the very reason for the existence of the university. To be always
involved in the organization of existing knowledge in teaching programs relevant to the real conditions of the people, the writing and rewriting of integrated curricula as these conditions changed would be among the most important and permanent tasks of a university defined as a learning institution of a people.

An educational program with a definite and explicit social purpose creates an atmosphere radically different from the one present in most educational systems. Not only do the educational activities integrate and apply knowledge to real situations and, therefore, motivate and facilitate learning, but the purpose of the program changes the attitudes of the professors and the students, and a mystique is slowly created. In most societies, personal gain and the desire to climb the social ladder seem to be the only reasons for the vast majority of those who enter the educational system. Although in the new system the desire to improve one’s social and economic status does not, and should not, disappear, it decreases in importance and finally occupies its proper place within a far greater social context.

In the case of FUNDAEC the results of such an educational system have to be examined within the context of the totality of the activities of the rural university. In order to do this FUNDAEC has dedicated a great deal of effort during the past three years to the support and the analysis of the different projects of its graduates. Towards the end of 1980 the future engineers divided the region of Norte del Cauca into seven zones and allocated two to four of themselves to each. A zone consisted of three to ten villages of about 100 families, giving each group responsibility for 2,000 to 6,000 people. The basic instrument of work has been a project presented by the group of rural engineers on behalf of their villages for periods of six months to a year. The first set of projects was prepared by the professors and the students as a final stage in the education of the engineers in rural well-being. The second set of projects was designed mostly by the engineers and already included opinions from the inhabitants of the villages. The hope has been that the projects for each zone would gradually include more and more of the aspirations of the inhabitants of the villages, keeping in accord with the principle that participation is not a mere technique, but an unfolding process, in itself the motive and the outcome of a continuous learning process, which utilizes knowledge and experience from within the community and from without, and is maintained by constant development of community structure and organization.

The structure of these projects falls within the same pattern that the rural university followed in its own establishment. In order to carry out its role as a catalyst, the rural university set out to analyze the processes of community life that exist within any given rural population. Thus, in the region of Norte del Cauca, it examined initially processes such as: production
in small farms, production (usually of animals) in small units by those who do not possess sufficient land, technological support to production, marketing and the flow of money and goods, the development of human resources, socialization and child education, decision-making, and flow of information. Without the existence of an institution of higher learning, these and many other processes would of course continue within the population of the region, and change and evolve as a result of a large number of social forces, the strongest of which, at this point in history, are from outside the population itself. The institution of learning created by FUNDAEC, proposed to set in motion a number of corresponding 'learning process'. These processes, often small in scope when compared with the social processes already in motion, are to have a strong dimension of analysis and conceptualization, and it is assumed that they generate forces that would influence positively the evolution of the 'processes of rural life' towards higher levels of well-being. The projects of the rural engineers have been exactly concerned with setting in motion in some of the villages of each zone such learning processes and slowly generating the forces that would bring about change. The actions of each project in general have fallen within one or more learning processes such as the search for alternative systems of production in small farms, the formation of a pyramid of workers in rural well-being, the strengthening of small units of production, the creation and strengthening of the channels for the flow of money and goods, the strengthening of family life, the detection of specific technological needs and search for concrete solutions, and the organization of the flow of information.

Although the period of self-evaluation has not ended, it is clear that FUNDAEC has, with great success, set in motion many of these processes, and together with its students, has gained valuable experience in managing them. Of special interest are the successes of a tutorial system for the formation of promoters of rural well-being within the process of the development of manpower. The tutorial system gradually evolved during the past three years as the engineers experimented with different methods of teaching the first year of the six-year program, corresponding to the first level of the pyramid of workers in rural well-being, outside the school in the villages themselves. The youth of the villages responded to the tutorial program enthusiastically and so successful has the effort been that an increasing number of engineers are being hired by other organizations to establish the program in nearby regions. In Norte del Cauca itself, an increasing number of villages are participating in the program and one can see the beginnings of an impressive educational dynamics carried out mainly by village youths themselves. In some of the villages where eight or ten promoters already exist, there are also certain attempts at creating youth organizations, receiving credit, and establishing production enterprises.
As the base of the pyramid of workers in rural well-being widens, the Rural University and its graduates find greater opportunities to set in motion the other learning processes and increase the range of their activities.

Yet, a basic question remains unanswered: can these processes indeed generate strong enough forces to counteract the forces of social disintegration? Strangely enough, from among the individuals and institutions who have in one way or another helped FUNDAEC, its own originators are the most critical and the least optimistic in this respect. Although they have never wished to attack any specific social or political group, they cannot deny that the hundreds of millions of rural inhabitants of the world are oppressed by a world system consisting of the two strong contending powers and their many subsidiaries and variations. By simple inertia or by design, the fruits of the hard labor of these millions are sucked away and are channelled to finance the thousands of mechanisms, including reform and revolution, used for the maintenance of the world system, and its favorite occupation, the production of weapons of destruction. Can the inhabitants of Norte del Cauca truly hope for a higher level of material well-being under these conditions? A simple transfer of a sum of money from one bank to another, or a political alliance at a moment of convenience generate irresistible forces that determine the prices of their products, how much land they can possess, what technology they can use, and which propaganda they should be subjected to. How can their fragile economy withstand these huge forces of disintegration? The people of Norte del Cauca have certainly proved with FUNDAEC that, once offered viable alternatives, they are willing to participate in the processes of change. But change at the village level is only half of the challenge of development. The so-called developed world, including the modern sector of the Third World countries, also has to change; in the final analysis, a prosperous village in Norte del Cauca can only exist as an organic part of a totally new world order.

The above remarks, of course, cannot be taken as a simple expression of pessimistic thought, as it is certain that change at the level of the village is, at the same time, an indispensable element of change at the global level. Thus, far from retraction, the future plans of FUNDAEC are for the consolidation of its work in Norte del Cauca and expansion to other peasant populations. The process of formation of promoters of rural well-being through the tutorial system is expanding rapidly in a few neighboring regions. The task of the final edition of some ninety units constituting the entire rural high school curriculum is pursued vigorously, making the transfer to the official rural system in many parts of the country a realistic possibility. An increasing number of private grassroot organizations are now approaching FUNDAEC with special interest in the tutorial program and some of the results of the process of search for small production systems.
An association of workers in rural well-being which was created two years ago, is slowly consolidating and taking on the implementation of development projects and the application of the results of the different learning processes. At an international level, FUNDAEC is also beginning to share experiences and improve its methods and its content. All seems to indicate, then, that the future of the institution looks good and the FUNDAEC should be congratulated for its efforts and its accomplishments. After all, the successes of an institution should be measured according to its size and its resources, and there is no reason to ask of FUNDAEC to solve the complex problems of an entire region. The problem is enormously complicated and institutions like FUNDAEC should not set unattainable goals and should be content with the positive contributions they make to development. Those who have participated so intensely in the FUNDAEC experience have by now learned to accept the validity of these statements. Yet one persistent question continues to haunt them. Where are we to find solutions that correspond to the real magnitude and the complexity of the problems faced by most rural populations?
UNIVERSALISATION OF EDUCATION PROBLEMS

AND REMEDIAL MEASURES

V.G. Kulkarni
UNIVERSALISATION OF EDUCATION: PROBLEMS
AND REMEDIAL MEASURES

Introduction

The Third World is pining for development; more specifically for a reasonable standard of living that will enable its people to shed the disgrace of being relegated permanently to a second class citizenship of the world. The development, whatever model of development one chooses, depends critically on the availability of trained and committed manpower that is difficult to generate in the absence of prosperity. The helplessness at being caught in this cruel circle and the multipronged nature of the curse of poverty are brought home when one realises that in many developing countries, it is only the very small traditionally elite class that receives some education. Public debates that attack this educational system and call it 'academic', bookish and irrelevant do little to console the vast majority of the poor who continue to remain illiterate, uneducated and deprived of any opportunity to participate meaningfully in any developmental activity. It is, indeed, fortunate that it is now being realised that there is an intrinsic contradiction involved in trying to develop human resources without casting one's net wide enough. It is in this context that universalisation of (at least) elementary education deserves to be the battle cry of the developing world.

Universalisation of elementary education is not an easy task. Quite apart from the considerations of infra-structure, resources and management, the problem of perception is of vital importance. In an environment dominated by factors such as poverty, a long history of colonial rule and an even longer tradition of social stratification, educational attainment acquires the character of a barrier beyond which only a chosen few could go. Those who belong to this elite group have everything to gain if this barrier acquires superhuman sanction, or prestige, or it it can be rationalised on the basis of some modern and prestigious school of thought. One can then take the stand that the prevailing stratification in the society and the consequent division of roles reflect accurately (and even predictably) the intrinsic abilities of human groups. Any programme for universalisation of education will have to deal with the task of removing this modern superstition.
The question to be faced squarely is the following: is education a device for elimination and the school system a pipe-line to filter the cream into higher education, or is it a tool for developing human resources? The need to change the perspective cannot be ignored or wished away, nor can one hope that educational reforms would transform automatically the perception of the society.

The Problem

Having realised the importance of universalising education, an all out effort is launched to achieve this objective. However, the perception of the task is basically wrong. It is conceived as a programme of giving more of the same to many more people. The emphasis is, therefore, placed on generating infra-structure, solving problems of management and above all on creating and mobilising resources. Aspects like undertaking research to identify the real stumbling blocks, increasing the relevance of learning tasks to real life situations, and relating education to productivity are often sidetracked. In other words, dissemination of a traditional package to cover larger sections of population gets precedence over identifying the contents of a package that can be universalised profitably. It is the contention of this thesis that ignoring these aspects has been one of the major causes for the alarming drop-out rate, wastage and stagnation in education, in spite of a tremendous effort to generate a gigantic infrastructure.

On the Indian scene, considerable efforts have been made, in the past three decades. A large scale expansion of primary schooling facilities to provide most children with a school within walking distance, updating curricula for science and mathematics, providing pre-service and in-service training facilities to a very large number of teachers, are some of the significant achievements. Attempts have also been made to keep the allied costs of education to a bare minimum, by producing inexpensive books of a high quality and by establishing schemes like, the book banks, free tuition, and in some cases free mid-day meals. In spite of all these efforts, a large section of the society has remained outside the fold of education, and educational reforms are losing credibility. Equality of education opportunity seems to have been confined to throwing the gates open and perhaps to minimising malpractices in an unfair race loading in favour of the traditional learners.

The system now needs a phase change. Extensions of old ideas, marginal changes in distribution of resources, and copying educational technologies generated (and often discarded) in the West, will not do the job. Having created the infra-structure it is now urgently necessary to identify socio-economic, cultural, linguistic and pedagogic factors that prevent the universalisation of education and to take appropriate measures to overcome these
factors. It is also necessary to identify the contents of an educational package in terms of language skills, science and technology information and numeracy, which would enable a common man to improve his economic condition by increasing his productivity in his own set up. If effective steps to bring about this phase change are not taken soon enough, the vast majority of our population, whose expectations have been aroused, will continue to be denied education. Such a situation could lead to dangerous and explosive consequences. The main problem consists of designing these new inputs (often called compensatory or remedial education).

A few illustrations would suffice to indicate the operational implications of the changes needed. As a result of large scale horizontal expansion of the school system, the profile of students enrolled in the first two grades in a typical rural school has undergone a big change. Majority of students are first generation learners who have special problems. However, the teacher training institutes have done little to equip the teachers to help these first generation learners. Instead, these students are often described as slow learners and are (at best) given repeated doses of the same inputs, sometimes at slow speeds. In-service training of teachers provides yet another example. A typical science teacher in a secondary school is called upon to teach all branches of science, and therefore, requires inputs in areas with which the teacher is not familiar. However, the orientation courses continue to give more physics to the physics graduate when he really needs some help in (say) biology. Similarly, attempts to introduce vocationalisation degenerate into offering watered down versions of outdated courses in technology. Students coming from the weaker sections of the society are expected to perform poorly. Remedial measures for them consist of a permission to proceed slowly and repeated inputs of the same type. The curriculum for the non-formal classes often consists of the formal syllabus presented in a formal way; the only non-formal aspect being the unconventional hours of instruction. It is hardly surprising that such efforts fail to yield desirable results.

There is, however, no reason to despair. The results of properly designed R and D efforts show that it is possible to design, implement and evaluate remedial measures to overcome specific hurdles in universalising education. The rest of this paper is devoted to a description of some of these attempts with which I am familiar. In the course of this description, the concept of remedial measures will, hopefully, emerge.

Encouraging Creativity

There is a general feeling that laboratory programmes in a typical school tend to be primitive, dull, and incapable of
promoting creativity in children. A survey of the secondary schools in the state of Maharashtra\textsuperscript{1} shows that most rural schools and a sizable fraction of urban schools do not have proper laboratory facilities. The problem, therefore, was to design ways and means to promote creativity, resourcefulness and an awareness of physical and social environment, and to involve not only the students but also the teachers, parents and the community. Nearly two decades ago, some motivated teachers in the city of Bombay, and a few scientists at the Tate Institute of Fundamental Research who felt concerned about the social aspects of science, came together to organise an exhibition in which school children could exhibit any project based on science. The education department of the Municipal Corporation of Greater Bombay was progressive enough to sponsor and house such an exhibition.

The story of school science exhibitions is truly fascinating. It had a very modest beginning. Schools had to be persuaded to participate, and the exhibits were often crude, unimaginative and gadget oriented. However, even in these modest beginnings one could spot the creativity of some students and one also noticed that several students coming from the weaker sections of the society showed refreshing ingenuity. Slowly but surely the idea took root. Many more schools began to participate. There were long queues of students and parents to see the exhibition. Soon the exhibition had to be organised in two different centres (north and south) in Bombay. Later, the Government of Maharashtra adopted this activity and spread it all over the state. The exhibitions are now held every year, at the Taluka level, the district level and finally a state level exhibition of all entries winning prizes at the district level is organised.\textsuperscript{2} In the city of Bombay, exhibitions have to be organised ward wise. It has truly become a movement.

The academic progress of this movement is equally satisfying. The exhibitions are no longer totally gadget oriented. A large number of projects based on the application of science and

\textsuperscript{1}HBCSE had conducted in 1976 a survey of all the secondary schools and school teachers teaching science/mathematics in the state of Maharashtra. Some of the findings regarding physical facilities available in the schools and the nature of work loads of teachers are revealing. The findings have been published in the 'Proceedings of the Khiroda Conference', ed. Dr. R.G. Lagu, HBCSE.

\textsuperscript{2}The prize winning exhibits at the state level are exhibited in the national exhibition. The movement has now reached a stage when exhibits prepared by students can sustain district level science museums. This logical consequence must be explored if so much energy and innovativeness is to find a permanent and productive expression.
technology to relevant problems are displayed every year. Through these projects students are developing an insight into the principles of science and are discovering real thrill conceiving and completing the projects. Moreover, this activity provides incentives and opportunities to collect information, to conduct open ended experiments, to understand major projects like the fertiliser projects or large multipurpose dams, etc. Also, most schools being poor, considerable ingenuity and resourcefulness is required to set up a working model. In recent years one has also seen a large number of investigative projects being set up in these exhibitions. Most schools and schoolteachers and many parents are realising that, time spent in setting up these projects is academically rewarding and that students participating in exhibitions do not suffer in the examination.

One more experience must be mentioned. It could be argued that rich metropolitan students with plenty of resources from the school and with a good backing from home would have an advantage over those from the weaker sections of the society. It is satisfying to note that such an effect has not been seen. Over the past few years the bulk of the prizes have been bagged by rural students studying in schools with poor resources. The movement is also fortunate that the hundreds of experts who have served as examiners have given higher weightage to human abilities. The effect of exhibitions on creating public opinion is also a very important factor. Everywhere there are long queues and thousands of students and adults come from long distances to see the exhibitions. The exhibits, the enthusiasm of students setting up the exhibits, their improved ability to communicate and the reward system adopted by sympathetic and knowledgeable judges has considerable influence on the public. The science exhibitions (at the state level and also at the national level) is, in my opinion, the single most important innovation in education, that combines the advantages of the formal and the non-formal channels and has a trend-setting capability. It is an important remedial measure that compensates for the shortcomings in the formal school curriculum. It would be interesting and academically rewarding to undertake a study of the impact of science exhibitions.

The Language Barrier

It has been mentioned before that remedial or compensatory measures should not aim at giving more of the same; the measures should be novel and aimed at overcoming or compensating for differences arising out of unfortunate socio-economic deprivation. The research project undertaken by the Homi Bhabha Centre for Science Education (HBCSE), to study the effect of language barrier on the universalisation of education, provides an example of such

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a remedial measure. It was noticed during the course of our field work that the language (Marathi) in which the science texts are written is more sophisticated than the language in the language-texts prescribed for the same grade. Obviously, if the language level in the science text is higher than that in the language-text, students would find it difficult to read the science book on their own. Encouraged by the results of a pilot experiment in which passages from the texts and the linguistically simplified versions of the same passages were tested for comprehension, HBCSE prepared linguistically simplified versions of the General Science texts (Marathi) prescribed for grade V, VI and VII. In preparing these simplified versions, everything else, that is, content, order in which concepts are introduced, lengths of chapters, pictures and illustrations were all held constant. The technical terms were also held constant. Only the language of exposition was simplified.

Thanks to the cooperation of the Government of Maharashtra and the Municipal Corporation of Bombay, it has been possible for us to undertake a systematic project to evaluate the effect of language simplification. Under this project, nearly 12,000 pupils are reading the simplified versions while an equivalent control group has been identified for comparison. The evaluation consists of a) comparing pupil performance in conventional examinations, b) comparing pupil performance in examinations specifically designed to test concept formation, and c) measuring increase, if any, in teacher pupil interaction and in changes in the behaviour of teachers and pupils, such as for example, using simpler language in the classroom, better pupil participation, etc. Tools for such an evaluation have been developed and an evaluation has been conducted. It may

These tools and the evaluation of the project have been published. See for example:

be pointed out that the project does not involve teacher training or any other conventional input.

The results obtained in this project are very encouraging. Pupils perform far better in conventional examinations; the number of pupils exhibiting mastery learning (scores of 60% or better) nearly doubles. Results of tests for concept formation are even more encouraging. The real gain, however, is in improved teacher-pupil interaction. Influenced by the simple language in the book, the teacher tends to use simpler language in the classroom which in turn encourages pupils to participate in the proceedings. That such a result could be obtained by merely simplifying the language of exposition in the text-book indicates efficiency of a remedial measure designed to overcome an identified obstacle. It must be mentioned in this context that language simplification helps all the students, the first generation learners as well as the traditional learners. While the former tend to drop out of the school system in the face of insurmountable obstacles, the latter are sustained by parental pressure and by the age old practice of concentrating on the articulation of the concept instead of on the concept itself. These findings should apply equally well to other texts. In fact, the importance of socio-linguistic factors in education is only beginning to be realised. We have a long way to go.

Problems of First Generation Learners

As a result of large scale horizontal expansion of the primary school system, the enrolment in grade one has gone up substantially. In rural schools and in schools catering to urban slums, most pupils in the first two grades are first generation learners who face several problems in the classroom. First of all, they are not familiar with the code of conduct followed in a formal class, secondly their language behaviour is not developed enough to enable them to participate in the classroom either actively or passively. A traditional learner receives at home all the inputs necessary to ensure school-readiness and a teacher accustomed to deal with only traditional learners does not realise the special needs of the first generation learners. The aspect of language behaviour is equally important. Here the remedial measure does not consist of adding to the vocabulary of the students for, their vocabulary is not particularly inadequate. What they need is training in acceptable forms of communication. Frustration of the first generation learners arising out of inadequate attention to their specific requirements can certainly be avoided.

With these objectives in view a curriculum development project was undertaken by HBCSE in a dozen villages around Khiroda in

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5A detailed report is being compiled. Readers interested in this report can write to Shri V.G. Gambhir at the HBCSE.
Jalgaon district in Maharashtra. In this project, non-operable parameters like, physical facilities in schools, nature of textbooks, educational qualifications of teachers, the nature of the examination system, the school hours, etc., were taken for granted. An attempt was made to incorporate into the teachers' pedagogy aspects arising out of the psychological and linguistic needs of the first generation learners. The teacher training programme was aimed at making them aware of these special needs and at introducing them to the operational implications of the new pedagogy. Most teachers have a strong desire to be effective and good teachers. They quickly saw the relevance of the new pedagogy and implemented it wholeheartedly. They made sure that their students understood the norms of behaviour in formal classrooms, were sympathetic to those who had difficulties in adapting themselves, and took keen interest in giving girls a little more than an equal opportunity. (Girls were traditionally expected to occupy a dark corner in the class and remain passive.) They also taught the students to speak in full sentences and to construct an argument. Once the language skills were imparted, most students could participate in the classroom proceedings and lively discussions followed. A special feature of this project was the development of specific tools to measure behavioural attitudinal changes in teachers and pupils. The project has now been evaluated using these tools.

This project was concerned mainly with generating a package of remedial measures to enable the first generation learners to take advantage of the free and compulsory programmes for primary education. Once again the compensatory measures consisted of inputs other than those given traditionally in a class. Simple aspects of teachers' behaviour such as accepting answers given in child language, treating all responses (expected or otherwise) with sympathy, giving weaker students sufficient time to respond to questions, distributing opportunities equally to all, go a long way to comfort the bewildered new learners. At least the push-outs can be prevented.

Remedial Measures for the Socially Deprived

In India a good fraction of the society has suffered for centuries a very severe social deprivation. People belonging to this class were denied education, had no rights to participate in the affairs of the society and were constrained to perform menial jobs. Since independence efforts are being made to compensate for centuries of deprivation. Prominent among these remedial measures are the reservations offered to people belonging to scheduled castes/tribes, at institutions of higher learning and also in jobs. However, the policy of reserving seats and jobs has created its own new problems. Those entering institutions of
higher learning on the strength of reservations are unable to complete the course, or take an inordinately longer time to
complete it somehow, while teachers keep complaining about falling
standards. Their peers are unhappy because the system of reservation deprives students with high academic records of seats
that they think were legally and morally theirs. Some remedial
courses are offered to weaker students on the campus of these
institutions with a view to narrowing the gap. These remedial
measures have not worked. Often the beneficiaries of such remedial courses revolt against the courses which they feel are an
evidence of discrimination.

Education cannot aim at human resource development unless it
caters to all sections of the society, and universalisation cannot be
achieved unless early drop-out can be prevented. Slogans and legislature will help create the climate; goods can be delivered
only if a large number of remedial measures based on R and D and evaluated in the field are made available. From this point of
view HBCSE undertook a programme to study the problems faced by scheduled caste/tribe (SC/ST) students, at the secondary school
level. The aim was to develop a package of remedial measures which could help these students to perform significantly better
in the school leaving examination. Under this project, which was started three years ago, forty students belonging to SC/ST, living in urban slums, and studying in class VIII of the Bombay Municipal Corporation schools were selected. In later years new batches were added and the research design was improved upon by adding equivalent control groups. The selected students spend one afternoon (after their normal school hours) at the laboratories of the HBCSE where they are given remedial instruction. The first batch of SC/ST students participating in this project appeared for the school leaving examination (SSC) held in March 1983. Their performance and the performance of students appearing for the S.S.C. examination from the BMC schools is given below in a tabular form. The table is self-explanatory and no further comments are needed to elucidate its contents. The project has been well documented and a short account has been published already.

It has been emphasised that remedial measures should not be more of the same but something very different and preferably of a catalytic nature. This aspect was kept in mind. Contact hours were limited to two hours and a half every week for about 30 sessions in one academic year. Care was taken to ensure that the package developed in this project would not be expensive in terms of human or physical resources. The experiences in the classroom were supplemented by interviews of the children and by surveys concerning their families and environment.

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6V.G. Kulkarni, 'Who says Science is difficult?', *Science Age*, October–November 1983, published by the Nehru Centre, Bombay. A detailed report is also under way.
Results of the S.S.C. Examination, March 1983
Comparison of performance of project students (Pr.St.) and students from the B.M.C. schools from which the project students were selected (BMC)

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>Percentage of students obtaining</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First Class</td>
<td>Second Class</td>
</tr>
<tr>
<td>SCIENCE</td>
<td>81 (Pr.St.)</td>
<td>19 (Pr.St.)</td>
</tr>
<tr>
<td></td>
<td>19 (BMC)</td>
<td>36 (BMC)</td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>59 (Pr.St.)</td>
<td>22 (Pr.St.)</td>
</tr>
<tr>
<td></td>
<td>10 (BMC)</td>
<td>14 (BMC)</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>31 (Pr.St.)</td>
<td>28 (Pr.St.)</td>
</tr>
<tr>
<td></td>
<td>6 (BMC)</td>
<td>10 (BMC)</td>
</tr>
<tr>
<td>Aggregate marks in all the subjects</td>
<td>50 (Pr.St.)</td>
<td>41 (Pr.St.)</td>
</tr>
<tr>
<td></td>
<td>5 (BMC)</td>
<td>22 (BMC)</td>
</tr>
</tbody>
</table>

It is known that amongst all the factors that govern the scholastic achievement of the student, the single most important factor is the home background. It was found that most students had parents with little or no education. The parents could not help their children directly which is bad enough. What is worse (and often not appreciated enough) is the inability of parents to understand the struggle which their children put up in trying to progress through school. This lack of familiarity with the process of education makes the parents insensitive to the needs of their children. They do not know when to praise or be sympathetic or firm or when to exert pressure. Also the socio-economically deprived students live in a poor environment where out-of-school inputs like availability of reading material from good public libraries, public lectures and debates by leading experts, cultural shows and the like are simply not available. Students live in a world significantly different from the world of the school with little help to correlate events, norms and behaviour patterns from the two worlds. These factors had to be kept in mind in designing and implementing remedial measures.

It was found that the students were extremely curious. They raised a large number of questions, some of which were very
intelligent, and exhibited a keen desire to learn. It was noticed during the course of discussions arising out of these question-answer sessions that, while the ability to profit from oral interactions was fairly well developed, the skills for reading comprehension and the ability to evaluate one's own experiences were still at a primitive stage. It was, therefore, decided to develop remedial measures to promote these basic skills and to study the effect of such measures on scholastic performance.

Discussions concerning language ability tend to over-emphasise the volume of vocabulary. It was found that the students had a reasonable vocabulary but lacked the ability of critical reading. If they read a passage of (say) 250 words, they could not extract the central theme in the passage and relate it to the incidental information in the passage or to life situations. To overcome this disability, the students were given a large number of simple books in Marathi. They were encouraged to read these books and summarise the contents (orally) and also to tell us what they liked and what they did not like. They were also encouraged to read the books aloud at home, and to explain the contents to their sister, brother or mother. Periodically they were given selected passages for reading and discussion. In two years, their reading skills developed considerably. They were able to read not only the story-books, but also the text-books and some of them even ventured to read lessons not yet taught in the classroom. This experiment in reading comprehension has three important operational implications. Firstly, comprehension depends not only upon symbolic decoding (recognising letters and words) but also upon cultural decoding which governs internal relationships of words (other than pure grammatical linkages) that decide pauses, intonations and similar non-verbal communications. Even at the risk of making an exaggeration let me say that traditional learners are introduced to these subtleties of language in their home background while the first generation learners and especially the socially deprived are constrained to learn these aspects as though they were learning a second language. Language learning is a basic tool. Social deprivation first hits at the language ability and lack of linguistic preparation takes care of the rest. Remedial measures must aim to compensate for this aspect.

The other two implications are equally important. Motivation of the students need not be doubted. They are hungry for books. In this context, the experiences in organising book exhibitions along with science-exhibitions tell the story eloquently. There are long queues and children just cannot be given enough. Every effort must, therefore, be made to organise libraries for children throughout the length and breadth of the country. Lastly, it was found that once students discovered the joy of reading, they treated the books with due consideration. Making available graded reading material to suit a large variety of tastes is not very expensive. Also most schools have libraries, but the books are not issued for fear of losing them.
It was found that in science, the major problem of students concerned symbolic language like, formulae, graphs, schematic drawings and chemical equations. In reality this symbolism is introduced to facilitate thinking. The teachers, however, are not made aware of the fact that this new language needs systematic introduction. The typical classroom instruction seldom contains a deliberate and systematic exposition of this language. On the other hand, introducing this language is relatively easy and if undertaken at the appropriate time, it can be accomplished quite inexpensively and speedily. Not doing so could lead to a very misleading picture. For example in grades, VIII and IX, students are introduced ray diagrams in optics. It was found that the real difficulty of the under-achievers was concerned not with the theories of optics but with the conventions (language) of geometrical optics. No one tells them that a plane mirror, and hence any plane reflecting surface like a lake, can be represented by a straight line. If this new language is not introduced at all, the three steps in problem solving (translating a real situation into symbolic representation - operating these symbols using new grammar - re-translating the final result into reality) remain a mystery. Once this skill is acquired errors arising out of 'linguistic obstacles' are easily eliminated. Unfortunately, most remedial classes remedy nothing. They play the same record all over again.

Mathematics is supposed to be a very difficult subject. Here, the real problem is visualisation. This problem is something similar to the problem faced by a beginner in chess, that of visualising the chessboard a few moves later. What such a player needs is practice, not one more lecture on how the pieces move. This hypothesis was tested by giving the students plenty of opportunities to visualise and to manipulate algebraic and geometrical patterns. They were encouraged to draw figures or write equations on the blackboard and were given full freedom to try any transformation that they thought would be helpful. The students decided upon the strategy and implemented it. This process was slow and only selected topics could be covered, but once the ability to visualise a geometrical figure or an algebraic relation between several symbols after these have undergone some transformations is developed, students begin to treat mathematical problems as ordinary puzzles and more often than not succeed in solving them.

Remedial Measures for School Drop-Outs

In spite of the enormous efforts that have been made to improve the credibility and accessibility of the school system, it continues to be plagued by an enormous drop-out rate especially in the first four or five years. Today, the country has a large population of young boys and girls in the age group 8 to 14 who for one reason or another could not continue in the formal stream
of education, and dropped out. Such a population exists not only in villages and inaccessible places, but also in metropolitan slums. Educated or otherwise, these children are going to grow into adults and feel frustrated when they find that lack of education prevents them from playing their legitimate role in several social institutions in spite of these institutions being organised in a participative mode. What kind of remedial measures could be planned for them? Methods based on 'more of the same' have failed in spite of incentives and other gimmicks. Obviously, the curriculum for these students has to be relevant and need-based, not only in the long run, but at every stage. Also it has to be non-formal in the true sense.

Unfortunately the non-formal approach tends to be equated with school timings, being restricted to classes organised in the late evenings. Such a perception leads to faulty design of the non-formal curriculum. It must be mentioned that important differences between the formal and the non-formal approach must be kept in mind, if the non-formal channel is to remedy the situation arising out of enormous drop-outs from the formal stream. For example, a formal school is planned for a decade of continued instruction based on syllabi that can afford to be concentric. The development could be gradual and questions of relevance are raised (hopefully) at appropriate places, sometimes only towards the end. On the other hand the teacher intervention in a non-formal class is brief and has to have a catalytic effect. The syllabus consists of skills and information that are absolutely essential and which would hopefully launch the subject on the road to life-long learning. The question of relevance is important at every step. Moreover, in the formal stream, the relevance of a topic can be justified on the basis of its utility in the higher grade, which is not the case in a non-formal approach. In addition there are two differences which make the two approaches qualitatively different. In a formal stream it makes sense to consider (though not to over-emphasise) a pipeline approach; the non-formal stream essentially prepares the participants for real life situations. In the formal stream one has a wide choice of instructional material that can be used in a continuous mode; inputs in a non-formal stream have to be discrete and selective and based on immediate relevance. These considerations have been taken into account in generating the remedial instruction programme for the non-formal stream.

This programme has been undertaken in collaboration with the Indian Institute of Education, Pune, in five clusters in Pune district of Maharashtra. HBCSE is primarily responsible for the science component. However, in view of the philosophy outlined above, science cannot be considered as a separable entity, it is a part of the whole. The curriculum has been designed in the following manner. (1) The syllabus prescribed for the primary stage in the formal system was analysed for learning situations. Those learning situations that failed to
meet with the requirements of the non-formal approach were eliminated. New situations (not included in the formal curriculum) were added. For example, pictures of different types of bacteria causing different diseases were removed since a common man is seldom required to identify them, while topics like scorpion bite, prevention of dehydration in diarrhea were added. A four page pictorial folder is prepared for each unit of learning. (2) A kit of apparatus using inexpensive and easily available material has been assembled at a cost of Rs. 30/- per kit. The basic philosophy is to demonstrate that educationally relevant and intellectually satisfying activities can be conducted using material readily available in one's neighbourhood. However, such a philosophy does not work in vacuum. Making available a seed around which growth is possible can achieve very good results. The teachers in this non-formal project have multiplied the contents of the kit several fold.

The difference in the pedagogy must also be mentioned. The pictorial folders are not read like a text. The main job of the teacher is to communicate the message in the folder using pictures, daily experiences and simple activities. In this sense, literacy is not a pre-requisite for participating in the class. If there are any attitudinal or behavioural changes expected as a result of 'learning', those aspects are emphasised. For example, two aspects are emphasised in the teaching folder on rabies; that the treatment must be taken before the symptoms of rabies appear and that there is no need to panic since one can begin to take treatment in three or four days during which time one can easily reach a district hospital.

It has been pointed out above that reading is not over-emphasised. The other side of the coin must also be presented. What does one mean by terms like 'literacy' or 'comprehension'? Is it merely the familiarity with the alphabet and an ability to encode and decode? It is perhaps useful to look at this problem from yet another angle. In one's adult life, one received a large number of written messages through advertisements, newspapers and other media. These media use alphabets, certain symbols and symbolism and often use diagrams and graphs. (I am not referring here to scientific literature. A commercial house may use histograms to convey that it can make enormous profits for me.) Literacy should imply an overall ability to decode the message (removal of illiteracy), an ability to comprehend its meaning and above all readiness to perform a critical assessment of the message (removing gullibility). Obviously all these objectives are difficult to be realised fully in any programme. The point of relevance here is the inclusion of these two other aspects of literacy that are often lost sight of in a formal curriculum. A deliberate effort has been made to introduce symbolic language in the pictorial folders on science-based material, and the discussions in the class do include critical analysis of the message.
Yet another aspect of language behaviour needs to be looked into. Most adults are not called upon to write an essay or to give a discourse on (say) the French revolution. They need the skills to write simple letters and to put forward their requirements orally before a government official. The emphasis on the formal curriculum on essays and other allied things has to be replaced by an equally strong emphasis on generating an ability to make a logically sound argument. Material based on science is ideally suited to develop this ability. The non-formal experiment being of a clean slate type, opportunities to develop and test these ideas are readily available.

The non-formal project is being evaluated systematically. The evaluation is not restricted to measuring the achievement of pupils, it is also expected to throw some light on the process of education. For example, it is hoped that the evaluation will provide us with a better understanding of how literacy is acquired. The evaluation is also aimed at measuring the teacher-pupil interaction as a function of some controllable parameters, which would enable us to discover causal relationships in variables. Such measurements are needed very urgently since developing countries can hardly afford to neglect optimisation of human and physical resources. It is also hoped that a few other questions would be tackled during the course of such investigations. For example, it is known that comprehension (as compared to simple decoding) being a higher skill, there is usually a big gap between the comprehension exhibited by students over short and long ranges. (Short and long passages, immediate recall versus long range retention.) It would be interesting to see if the new pedagogy developed in this project can help develop comprehension. Similarly, it would be rewarding to see if science-based material can motivate and sustain literacy and if seemingly abstract skills like discrimination, ability to spot similarities and differences, an eye for detail do in fact prepare the new learner for life long education in the real world. That would be the true test of these remedial measures.

Concluding Observations

Having stressed the need for developing a system of education that would take into account the needs of the country, the aspirations of the people and the availability of resources, we have discussed a few examples of remedial or compensatory measures. We have attempted to develop a theme that remedial measures should be innovative and based on proper diagnostic studies, and should not consist of more of the same, or the same inputs given at slow speeds. This difference between the two approaches is more fundamental than one realises. The first approach believes that there are slow learners, that the educability of the socially deprived has been hampered by continued deprivation, and all that is really needed is tolerance and sympathy and perhaps an opportunity
to learn at one's own pace. I do not believe in this model. It is my personal belief that the concept of remedial measures is better illustrated by the following example. Consider a race in which a total stranger has been allowed to participate. Sympathetic planners have given him a decent outfit of sports clothes and shoes. No one, however, has told him or taught him to tie his shoe-laces. The new runner is finding it difficult to compete; he is falling down so often. The remedy consists not of lowering the standards, nor of letting him run slowly at his own pace, but of teaching him to tie his laces. Having done that, I will not be surprised if the new runner does well. This example is by way of analogy. However, it must be recorded that we have experienced this phenomenon many times. Several remedial measures, each ridiculously insignificant, go to compose the total remedy. And above all, the society should be made aware of the hidden potential of the first generation learners. If the teachers expect them to perform better, they will fulfil the prophesy.

There is yet another reason for undertaking these programmes on a war-footing. In an underdeveloped society those who are fortunate enough to survive the educational system have everything, a job, a decent income and all that goes with it, and the ability to provide suitable opportunities to their children. The drop-outs drop out of everything. On the one hand this polarisation is increasing day by day. On the other hand, modern mass media and socio-political propaganda is increasing the awareness of the masses. In such a volatile situation it would be wrong to expect the uneducated masses to exhibit a deep understanding of cause-effect relationships (which eludes even the elite). Once an angry mood is set, they are likely to put their finger on any one of the numerous differences and demand a specific remedial action for it. Waiting for such demands to grow and then attempting to meet them half-heartedly or trying to pacify the demands would not be rewarding. Recent public demands for English medium primary schools in villages, insisting on western style uniforms in rural schools, opposition to streaming (A and 0 level) proposed in the white paper of the Government of Maharashtra nearly fifteen years ago, are all examples of this phenomenon. If reason does not prevail at the top now, it would be futile to reason with the consequences later. The time to act is now. Fortunately, experiences of research groups undertaking innovative intervention type of work do paint an optimistic picture.

Acknowledgements

I have borrowed heavily from the experiences of my colleagues. I am particularly grateful to Shri V.G. Gambhir, Shri S.C. Agarkar and Dr. Jayashree Ramadas.
ROLE OF THE SAEMaul TECHNICAL SERVICE CORPS

IN KOREA

Hyung Sup Choi
ROLE OF THE SAEMAUL TECHNICAL SERVICE CORPS

IN KOREA

The term technology transfer is often used in a restricted sense to mean introduction of technologies from foreign countries. However, of equal consequence is the intra-national transfer of technology, which may take place as an extension of or independently of transfer of technology from abroad. Knowledge and experience gained by various scientific and developmental activities in the communities concerned need to be diffused to other communities throughout the country, particularly, to those of rurality. Effective diffusion and dissemination of technical knowledge and experience accumulated can improve the understanding of the importance of science and technology by the general public and, in particular, by the people in the rural community. Understanding of science and technology has become an increasing necessity for everyone in this day and age of technology. Undoubtedly, a better understanding of technology by the people can bring about progress and development of the rural community, which in turn, makes the desired balance possible in development of the agricultural sector keeping pace with the industrial one. With this perception as a background, the Saemaul Technical Service Corps (STSC) has been conceived and organized in 1972 on a voluntary basis.

The purpose of the Corps therefore was, in the first place, to disseminate on behalf of the rural community the technical information and knowledge which was acquired by the urban and industrial community through its economic development activities, to help the agrarian and fishing communities not only to improve the methods of farming and fishing but also to support the community people in developing skills for subsidiary work and skills for indigenous cottage industries for an increased income, thereby elevating their standards of living. The Saemaul Movement or the New Community Movement, of which the Corps is a part, was initiated in 1970 in an effort to galvanize the village farmers into a new improved way of life and to boost their work efficiency and hence their income level. To attain this, the basic spirit advocated was that of diligence, self-reliance and cooperation. The Movement was carried on nationwide in its scope and scale. For a long time in the past Korean farmers had suffered from poverty, inefficiencies and force of old habits which were inherited from the early era of feudalism. The rapid
industrialization of Korea which began in the 1960s had not altered this situation too significantly. The Saemaul Movement was set off in the rural areas initially but spread rapidly into urban life. The Movement served as a turning point in the process of modernization and industrialization and is affecting nearly all sectors of Korea. Clearly the Movement has changed the rural community markedly.

The Saemaul Technical Service Corps is an added dimension with the aim of equipping the rural population with scientific knowledge and technical skills. With the aid of these means, they can help themselves in order to better themselves.

1. Organization and Projects

STSC was established voluntarily in line with the above-mentioned purpose in April 1972, with the Federation of Scientific Societies as the coordinating agency. The Federation consists of 140 academic and professional societies in scientific and technological fields and has a membership of more than 80 thousands, which represents an aggregate of Korean scientists and technical manpower. The majority of these members are professors. At the beginning of establishment, STSC took an active part in organizing a committee of representative figures in fields closely related to the development of rural areas. By utilizing the committee it gave guidance on technological problems which occurred in the process of performing the activities by means of exchange of letters, broadcasting and newspaper. It also published technical guidance books by gathering and organizing technical informations. Activities of the head office in Seoul, however, could not satisfy all the needs of community as demands for their work increased, branches of STSC were organized in 1974 with provincial universities as executing body, and then a national network with 1,700 members was secured. In the head office of STSC, special subcommittees such as agriculture and fishery, improvement of environment, Saemaul factory, hygiene and synthesis were organized, each of which supported activities of provincial branches and played a role in diffusing technology through publication of technological data, broadcasting and newspaper. Members of each branch paid visits to the community and gave farmers and fishermen necessary guidances in bottlenecked areas at proper times.

2. Contents of Technical Guidance

The contents of technical services performed by STSC are as follows:
A. Farming & Income Increase

<table>
<thead>
<tr>
<th>Project</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production of main grain</td>
<td>Problems in productivity, processing and preservation (technological aspects)</td>
</tr>
<tr>
<td>Stock breeding and sericulture</td>
<td>Review of profit (economic aspects)</td>
</tr>
<tr>
<td>Forestation</td>
<td>Appropriateness on regional characteristics</td>
</tr>
<tr>
<td>Special crops</td>
<td>Problems in marketing (production, distribution and marketing system)</td>
</tr>
</tbody>
</table>

B. Technology on Improvement of Environment

<table>
<thead>
<tr>
<th>Project</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of agricultural base</td>
<td>Standard design</td>
</tr>
<tr>
<td>Improvement of housing and cattle sheds</td>
<td>Utilization of proper building materials</td>
</tr>
<tr>
<td>Common facilities</td>
<td>Landscape guidance by type of facilities</td>
</tr>
</tbody>
</table>
C. **Saemaul Factory Technology**

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3. **Outline of Projects Undertaken**

**A. Technology consultation**

STSC opened a technology consultation office in the head office and provided farmers and fishermen with detailed explanations of utilization methods of technology inquired through telephone, letters, etc.

As of August of 1978, 1847 cases were processed.

**B. Technology diffusion through mass communication**

STSC reported the common technologies for the problems met in the process of performing activities such as principal agricultural technology by season, forestation, cultivation of special crops and subsidiary household work of farmers through mass communication media.

It also provided necessary information closely related to increasing farmers' and fishermen's income through the network of Seoul Shinmoon (newspaper), Saemaul Weekly, monthly magazine Saemaul, etc.

**C. Publication of technology guidance data**

STSC publishes and distributes Saemaul technology handbooks every year since 1972, which contain various technological information necessary for the farmer and fisherman and make significant contribution to solve technological problems occurred in the process of undertaking their production activities.

Especially in 1977 STSC gave out pamphlets (bulletin) containing addresses and telephone numbers of specialists for farmers and fishermen to have direct contact with at any time. In 1978, it published a technology guidance selection by classifying the cases by contents.

**D. Technology guidance in the field**

In the beginning of establishment, activities of STSC were confined to indirect supports such as technical consultation services through broadcasting or publication of technology guidance books.

In reality, in spite of great efforts by inhabitants, many of Saemaul projects did not succeed because of technological difficulties or inefficiencies. Hence STSC has undertaken a measure of sending members in response to request by the
inhabitants, and has helped them give technical input in the field.

A total of 2300 of its member scientists and engineers, were sent to the field for about 1000 cases in 1977, to help solve the technological problems in rural areas.

Since most of STSC members consist of experts in their fields, their activities bring about more effect than expected through solving various complex problems faced as well as inquired by the inhabitants.

E. Establishment of sister relationship of one community with one member

Considering the necessity of continuous support in the long range, a scientist who is a member of STSC takes charge of one community for the technology problems.

Communities concerned were selected based on the expected development effects and scientists were linked, if possible, to the villages closely connected with them.

This project has resulted in setting up sister relationships of 140 communities with scientists in 1975, which nearly correspond to the number of communities called Kun in Korea, and the figure was increased to 300 communities in 1977. At the presentation seminar of successful cases in 1978, this sister relationship project was evaluated as the most effective measure in the program, which could achieve the familiarity, full knowledge and concreteness. This project expanded into the communities of 1300 over the nation by 1981.

F. Study on an adaptation test of the project of regional specialization

In order to spread and diffuse technical know-how to increase farmers' income, it is necessary to test a designated subject for a certain period in each region, so MOST had each provincial branch of STSC select and study one topic pertinent to each regional characteristics.

According to this survey performed from June of 1975 to May of 1976, each branch selected a subject area in each province for investigation. Subsequently they studied the latest agricultural technologies on soil sowing, fertilization, and prevention of breeding and extermination of vermin in the farming, and performed broad studies such as machine operation, quality control in Saemaul factories. In addition, overall development plan of the communities is helped to be formulated. The project has a specific aspect different from other development
projects in that it operates not only investigation (survey) of the topics but also technical education of inhabitants, so this gives them great benefits to being sufficiently equipped with ability of digestion and application of the new technology.

Such a project of regional specialization as well as an overall development plan should be expanded to the point that the results of the study are diffused and applied immediately into the community concerned and that the project can make a contribution to the inhabitants' needs by taking part in the experimentation.

4. Evaluation of Performance

A. Presentation of technology guidance cases

The guiding activities in the field have commenced on a full scale from 1974 with the branches of STSC as the central institution. But because organization of STSC's structure and contents of the activities of each province are quite different and various, it is liable to lack in mutual linkage between the branches of each province.

Under the view of being able to attempt more effective development by cross-evaluating the contents and the methods of projects performed in each province to the public, a seminar is held every year. There the participants analyse and evaluate the performances done so far and determine the direction for the next year. Special lecture on Saemaul Movement and technology guidance cases undertaken by provincial STSC are presented in a seminar attended by leaders of Saemaul Movement, local officials and professors as well as members of STSC.

Since each member of provincial STSC performs his activity suitable for each regional characteristic and with his expert knowledge, this seminar can give each member an opportunity of acquiring new technology guidance information.

B. Cases of success

a) Increase in yield of water melon by grafting and raising seedlings:

Some high-profit vegetables such as melon have been in cultivation for more than 10 years in Shinchon Ri, Choonsung Kun, Kangwon Do, with no improvement of technology during this time.

This means that the same varieties have been cultivated continually in the same area by the same method. Farmers came to a point where these could not be cultivated any longer due to the phenomenon called 'natural decrease in the rate of return' and to the diffusion of such disease as anthracnose and others. At that
time the specialist assigned to that particular village gave technical guidance and melon and watermelon were grafted and their seedlings were raised into pumpkins which was called 'New Tojoa'. This resulted in increase in the annual income of a farmhouse-hold from less than W 970,000 to more than W 1,600,000.

b) **Income increase through improvement of planting system:**

Okpyong Ri, Bosung Eup, Bosung Kun, Cheoranam Do is located 180 meters above sea level, so this region was unsuitable for grain cultivation of rice and barley due to much changes in atmospheric temperature. In consideration of this regional characteristic, the planting system of that region was converted into fruit-bearing tree cultivation such as persimmon and chestnut, and medical herb cultivation such as a herbaceous peony, which resulted in doubling the annual income per farmhouse-hold.

'Seed potato' field was set up in Sam Geo Ri, Moopcong Myon, Moojoo Kun, Cheorabuk Do located 700 or 750 meters above sea level, which brought about income increase of the overall village. The region became the only cultivation region of 'seed potato' in Honam region.

c) **Income increase through analysis of soil:**

A survey done by a responsible professor showed that underdeveloped rice, poor crop of paddy field, rice crop per 'dan' (≈ 0.245 acre) of only less than 240 Kg and severe damage by harmful insects resulted from bad soil. Through analysis of soil, the professor revealed that the paddy field lacked zinc, phosphorus, potassium. So a vegetable testing garden was set up to complement this deficiency, resulting in an increase of 423 Kg to 516 Kg crop per dan.

5. **Forward Directions**

Since the policy objective for the development of fishing and agrarian communities lies in establishment of welfare done through income maximisation by the modernization of farming technology, we should exert ourselves to permeate and diffuse the science and technology into the community, and should reinforce the activities of Saemaul Technical Service Corps.

In line with this concept, STSC should lay emphasis on the following to diffuse technology.

A. **Extension of sister relationship with one community by one scientist**

It has already been shown that the performance of sister
relationship project was successful. The reasons can be analyzed by three factors.

First, since the Corps consists mostly of high intellectual professors who are experts in their respective scientific and technological field, it is easy for them to cope with technological problems and suggest alternatives to handle. Their persuasive capability has a great influence on the villagers. So villagers can drive the suggested projects with a sense of confidence.

Second, as most members are linked to their own community, their enthusiasms are motivated by love for their home county and also because of opportunities to practice their expert knowledge the service activities are of use for themselves and thereby it is carried out very positively.

Third, the villagers also take positive attitudes toward solving problems with hopeful results from application of new knowledge. Partnerships between villagers and members of STSC are being formed more firmly. In the future the project should be taken more resolutely to establish the countrywide relationships of all 35,000 communities. In other words, the people at the grass roots level learned much from having presented their problems to those from the universities while the university people in their turn obtained invaluable insights into and lessons on how education should prepare people to solve practical problems.

B. Technology support measure for low-income community

The Saemaul Movement is a cooperative as well as a voluntary drive motivated by the desire for better life.

Thanks to this movement, the income of farmhouse-hold has greatly increased. However, there still remain 215 low-income communities where annual average income per household is less than W 1,100,000 as of 1978. So, STSC, first of all, should set up a technology support measure against these communities.

C. Modernization of technology guidance method

Technology guidance of STSC takes various forms such as help through sister relationship, guidance in the field, guidance through mass communications, etc. However, due to not only the limitations of guidance activities in the view of distance, time and places but also repeating same technical guidance to every individual, the technologies were not diffused well all over the country.

Therefore the technologies could be permeated and diffused all over the country more rapidly by devising efficient mechanism such as utilization of VTR equipments and so on.
D. Construction and exhibition of the model of advanced welfare community

Our village structures have 5 thousand years of historical background. The backgrounds of their creation are as follows: village formation by clannish unit, unplanned village formation due to the geographical conditions or natural demand, etc. In consideration of high population density in Korea, the present situation of village structures scattered randomly through woodland or mountain should be reformed by the overall improvement plans such as structural reorganization designed to enlargement of cultivation area, road network improvement for distributive machinery, and region-adjustment plan for elevation of group cooperative function. We must therefore not only seek the reconstruction plan through the analysis of present structure, but also consider the provision of new structure for modernizing the community.

For achieving this plan, we shall construct and exhibit the model of advanced welfare community through application of experience and knowledge of the advanced countries, which leads us to participate in the construction of welfare community in the 1980s.

E. Special measures for rural industrialization

Along with the improvement of productivity in agricultural production or modernization of farming, special attention should be given to the increase of farmers' income for better living by establishing proper industries in the rural areas. In this regard, the close linkage between agricultural and industrial sector is desirable in the form of development of linkage industries between urban and rural, decentralization of industry, fostering cottage industries and so on. With these thoughts in mind, STSC should devise an adequate mechanism to help rural people to this end.
RESEARCH IN DEVELOPING COUNTRIES

INNOVATION AND COMPARATIVE ADVANTAGE

Dinesh Mohan
RESEARCH IN DEVELOPING COUNTRIES
INNOVATION AND COMPARATIVE ADVANTAGE

ISSUES FOR DISCUSSION

Preamble

India as a continental economy has in the past three decades made some notable achievements:

(i) It now has the twenty-second largest industrial output in the world (World Bank Figures)

(ii) In real terms it has about the tenth largest scientific manpower (my guesstimate).

(iii) Almost all boys or girls who can afford to feed themselves and buy a few books at their parents' expense can get post-secondary university education in some college, university or institution. (This probably does not have a parallel anywhere else in the world.)

(iv) Almost all consumer items sold in India are either made in India or assembled in India. (This is probably not so anywhere else except in China and the Soviet Union.)

However, these achievements have not resulted in:

(a) making careers in research, development, and innovation popular or respected,

(b) bringing down the prices of products dramatically,

(c) the production of even a single manufactured good which is in demand internationally,

(d) the production of a large number of goods which can be purchased and used by a majority of the people,

(e) the reduction of demand for foreign collaborations by industry or academic institutions,

(f) the consolidation of academic institutions as indispensable to society and the state (witness the lack of dislocations when such institutions remain closed).
These points are not being made to belittle our achievements but to force an introspection and a re-evaluation of our directions. At this point it is worthless debating whether heavy industrial infrastructure and higher education should have been given so much importance in the Nehru era. It is my belief that sooner or later these would have had to be developed and we can only discuss the optimal timing for such developments. However, large continental economies have more surviving power than smaller ones and so mistakes do not necessarily bring doom.

I also believe that given the first three five-year plans major shifts in industrial and educational policies should have been made in the late sixties and early seventies. These changes were not made and so we are today in a situation which is basically a charade of the situation obtaining in the late fifties and early sixties. Instead of distributing goods and services more equitably to a larger section of the people we are moving towards a Brazilisation of our economy. But luckily we have in our midst politicians like Raj Narain, Charan Singh, Chandrashekhar and others and activists like Datta Samant, Sharad Pawar, Niyogi, etc. who provide some declaration to this movement. We have to use this respite to change our direction before such forces are made to disappear.

To promote a discussion on such issues I list below what I think are some of our strengths and weaknesses.

**Strength of the System**

1. In almost every field of scientific and technical endeavour there exists a reasonable number of experts who are excellent by any standards (their proportion to all of the people working in that field may be very small, however).

2. People have gained experience in the manufacture (even if passive) and repair of a very large variety of technical items. These range from the miniature to massive and simple to the extremely complex.

3. An open society has permitted the accumulation of ideas and literature in India.

4. There is still a great deal of freedom in academic, industrial (both public and private) and government institutions.

5. There exists an infrastructure which is capable of supporting any large and complex technical undertaking even if all ties with the outside world are snapped for some time.

6. A large number of innovative academic, industrial and institution management experiments have been attempted by some very gifted
people. The experiences of these experiments are available for debate and choice for the future. This has happened in spite of the fact that a vast majority of the mainstream industrial and academic institutions have been very conservative and slothful.

7. There exists a long tradition of intricate and complex craftsmanship in almost all materials. This storehouse of expertise and pride can be channelled into tackling the production challenges of the late twentieth century.

8. A large number of professionals (small in percentages) have moved out of the established institutional framework and are operating out of small activists groups. These people have accumulated a very different kind of experience which links education-science-technology-culture-politics with survival.

9. Politicians are still very important in India. Though politicians are blamed for everything, it is only the politicians who can make others (including scientists and engineers) follow a dream.

10. The existence of a large number of distinct languages and cultural practices helps in looking at the same problem in different ways. This has partly helped the vast majority of Indian people in not falling into the monoculture trap of the elite.

11. In the decades to come India will retain a population distribution in which young people constitute a majority of the population. This will ensure the emergence of youthful ideas and exuberance. Very unlike the rich nations of today which are moving towards a society of old peoples' homes, stodginess, and conservatism.

Weaknesses of the System

1. Existence of English as a medium of scientific, academic and serious communication. This focuses our eyes only on the U.K. and U.S.A. as sources of knowledge. It also keeps out most people from participating in knowledge exchange. It should be quite clear that it is not possible or feasible to teach English to a vast majority of the people in a way that makes them competent to operate in the language like the elite of today.

2. The formal university system has expanded far beyond what the skewed income distribution of the country can tolerate. This unnatural expansion has given the higher education system very strong self-destructive tendencies (see my paper in Journal of Higher Education, Monsoon 1983, for an elaboration of this theme).
3. The scientific and technical establishment is extremely bottom heavy in quality. Innovation is only possible when there is a very large number of fairly competent people and much less dead weight (see my paper in Seminar, February 1981).

4. Private industry is coddled far too much and has no incentive to innovate. Very often what they list as innovations are not really so (see M. Bhagawan's paper in Seminar, February 1981).

5. Copying, plagiarism, and fraud in science has become far too common and accepted as normal in the best of establishments (some influential medicocrats admit in private that at least 70% of the M.S. theses written in India may be based on fabricated data). This is reflected in the fact that a majority of our senior and well known scientists have been implicated in unsavoury controversies which question their integrity.

6. Most of the brightest people are not entering careers in science and technology. They are being lured to trade, advertising and sales. This is partly because scientists and engineers are not being given challenging work with an objective in sight in industry or academics.

7. It is far too easy to import designs and know-how for almost anything needed in the country.

8. Research and development institutions are not accountable to societal needs. They only have to maintain peace and satisfy the auditors.

9. There is an unnatural and undesirable weightage given to 'basic research' which is actually not useful/needed/basic here or abroad. Hence even applied scientists gravitate towards proving their machismo in mathematical acrobatics of little consequence (Ronald Dore's thesis regarding importance of basic research in India is worth mulling over).

10. Information dissemination in science, technology, vocational expertise and other societal issues is very weak in India (see comparison of Information Infrastructures in India and China recently published by Research Policy Institute, Lund, Sweden).

11. There are far too many people who are illiterate and who cannot improve their skills and knowledge by self learning in India. There is absolutely no excuse for the lack of progress in primary education except criminal neglect.
Proposed Alternatives

India cannot live for too long on World Bank advice and IMF loans. Nor can it promise a better future for its citizens if it has to depend on handicrafts and garment export and tourism and non-resident Indians for foreign exchange earnings. These sources will force the Indian wage rates to remain very low. India will also have to depend on import of items like transport planes, oil, some heavy machinery, and murder technology (euphemistically called defence equipment) for quite some time. We cannot become completely self sufficient and so the only way we can become self-reliant is to exchange manufactured and processed goods for manufactured goods from the outside world. This will require a great deal of innovation in technology.

1. Abolish English as a language of education and intellectual communication and let pieces fall as they may. Teach English as a foreign language that it is.

2. Teach many more foreign languages in schools and small colleges around the country.

3. Translate scientific and technical material and literary works from countries other than U.S.A. and U.K. into regional languages.

4. Put much greater restrictions on import of plants, equipment and know-how from abroad.

5. Do not assemble or manufacture useless consumer items meant for the elite. Import them if the elite can earn foreign exchange from some other activity (assuming elites retain much of the power they have now).

6. In a few selected areas where foreign technology is distinctly much more efficient than what can be produced locally for some time free import should be allowed.

7. In areas of strength and great need like the railways, agricultural equipment, textiles and building construction, etc., ban all further import of plants and know-how. Launch ambitious, innovative and long term research and development projects which may result in unique products in some of the areas. These will solve local problems and will become respectable sources for earning foreign exchange. For example, can we develop railway carriages in such shapes that dust is kept out aerodynamically? Such stress on innovative big projects will automatically spur real basic research.
8. Reduce the number of colleges and universities offering bachelors and masters degrees by at least fifty per cent. These institutions so rescued from useless work should be made to offer a variety of courses ranging from very short term (e.g. one week) to diploma courses of six months or one year duration. These courses could be both vocational and in basic areas. They could then be used for improving skills and knowledge in small packets by people spread out over a long period of time while they are occupied in income earning jobs also. This must go along with a policy of literacy for all within the shortest possible time.

9. Do not give foreign exchange for study abroad. Only those should be allowed to study or train abroad who are sponsored by an employer.

10. Make research institutions more accountable by assigning goal oriented development projects as consultancies and tie yearly budgets to success in such activity.

11. Reduce murder technology expenditure.
SCIENCE, TECHNOLOGY AND EDUCATION RESEARCH

IN INDIA

A DISCUSSION PAPER

New Delhi, August 1982

Kenneth King
Introduction

Even a few days of listening, reading and talking in India can throw up a host of issues related to science, technology and education (STE). Concerns about STE are clearly very near the surface. Within this short period there have appeared: (1) the latest controversy in a round of intense debates about Nehru's plea for 'scientific temper'; (2) an attempt at a national level to prevent some engineering colleges from charging up to 10,000 dollars as capitation fee - so fierce is the competition to enter the prestige science and engineering sector; (3) a twenty page feature in Business India on the Indian Institute of Management (IIM), covering all the issues that emerge whenever prestige training and Indian industry are examined: brain-drain to U.S. industry, student disenchantment with 'managing' rural development and social welfare, creativity and its lack; discrimination in admissions policy, and the role of liberal education in the ordinary university sector.

Without prompting, the intellectual community and policy makers on science and education planning link the alleged malaise to a combination of structural and educational factors. The world's third largest stock of scientifically-educated manpower is frequently caricatured for being mediocre, unable to compete internationally, and having no particular comparative advantage. In almost exact parallel, the products of industry itself are equally criticised; they are mass-produced like the products of the education system, and like the latter they lack quality and finish. The pass mark in the school leaving examinations is 35%, and the poorest colleges will accept students at this 'pass' level. Similarly, weak quality control allows goods into circulation that are very poorly finished. Quality control is set very low, and the general image of industry is of low standards, and of a lack of concern with international competitiveness. Of course both education and industry are more differentiated than that. They combine relatively small 'elite' sectors which seek to remain on the gold standard (for example, TATA enterprises and the Indian Institute of Technology (IIT)) along with a mass sector that has allegedly gone off the international standard.

1July, 1982.
Paradoxically, India has done what many other Third World countries are berated for not having done. She has in general not tied her school and college standards to some high cost western benchmark, and consequently is able to offer many of her people some of the cheapest school and college education anywhere in the world. In parallel, where Indian industry is most internally competitive, there is the possibility of purchasing an enormous range of goods at very low cost, even if of very variable quality.

No one doubts that the patients (education and industry) are very much alive. Indeed they both demonstrate a frenzy of activity. The worry rather is about content and direction. There is a desire on the one hand for an internationally competitive scientific research community and a similarly export and quality oriented industrial sector. But this coexists with the view that Indian science (and by extension, Indian industry) is in reality a sea of mediocrity, and that somehow this failure to be innovative and to produce quality products is education-based. Analysts know only too well that, to an extent, colonial education deliberately excluded the quest for innovation and creativity (engineering college syllabuses, for example, were organized around maintenance rather than design work). But in the 35 years of independence, the desire for industrial and scientific autonomy has been somewhat inadequately fulfilled by the school and college system. Dinesh Mohan of IIT Delhi implicates the school system quite directly:

One cause of mediocrity at the college level is that we seem to have expanded our post-secondary capacity very fast without inculcating the scientific temper in our primary and secondary schools. Education for the student, all too often, is instead an exercise in memorising information uncritically, for its own sake. We have failed to make quality education available to the majority of India's children. (Mohan, Seminar, February 1981, p. 6.)

On the other hand, despite not being internationally competitive, Indian scientific capacity for all its numbers has allegedly made little dent on the mass problems of poverty, disease, drought and energy. The 'Statement on Scientific Temper' drawn up by twenty leading scientists and widely publicised since July 1981 made the point very starkly:

We have all the technology available right now within the country to give water, food, shelter, and basic health care to our millions. And yet we do not. Something has gone wrong. (Mainstream, July 15, 1981, p. 7.)

In sympathy with this conclusion, but reaching it from a very wide spectrum of political philosophies, are any number of organizations, voluntary societies and individuals who have sought...
to make science a much more powerful and popular vehicle of development. Indian science despite not attracting accolades internationally does not apparently even have the satisfaction of having taken itself to the people. This failing is the spark for a host of almost uncoordinated attempts to bridge the gap between scientific knowledge and poverty. Some use the formal school, some non-formal education with adults. Some treat 'science' as a weapon of awakening as Freire treated 'Literacy'. Villages are adopted to prove the value of applying relatively high technology to village backwardness, others to demonstrate that the scientific improvement of traditional technology is the way forward. A mass movement for people's science in Kerala vies with young scientists who have left the cities to work with one subdistrict, or with one scientist trying to run a personal primary school exposing just ten children to scientific methods.

The scientific apparatus is equally varied. Overhead, the Indian satellite will from August 1982 use 'high' technology to get development films to a certain number of states with receptors supplied. Elsewhere simple primary science kits in plastic bottles with 30 experiments emerge from the science education centre named after one of India's most famous nuclear scientists, Bhabha. Elsewhere again physics, chemistry and biology are taught without a lab, and without any materials for practicals at all. Yet physics, chemistry, biology and maths are all compulsory up to grade X, the school leaving certificate.

Lower down the training and industrial systems, India has massive resources of skilled people, some in traditional handicrafts, some in the modern sector. In industry in particular, the tradition of developing skills on the job is firmly entrenched, and a whole system alternative to formal training exists for producing people roughly equivalent to skilled worker, technician and engineer. The latter, termed 'engineering practical', underlines a further point that is part of this complex interaction of skill, technology and education. There is a widespread feeling that trained people do not work in fields they are trained for. Engineers work as inspectors, supervisors or on sales or marketing because the less formally trained 'engineering practicals' take their place. At the apex of the engineering training system in the IITs, a significant number after graduating go straight to the other apex institutions for management training (IIMs) and thus become managers rather than engineers. The system whereby a large group of the same people get both the best engineering and the best management training has been termed 'gold-plating gold'.² By contrast, the whole routine maintenance sector, from cars, to phones, to buildings and electrical machinery is serviced by people with few formal skills, and who, moreover, are seldom likely to possess any of the products they are said so inefficiently to be maintaining.

²Business India, July 1-18, 1982, p. 54.
This enormous informal alternative sector in Indian industry, and its learning and training methods are clearly another ingredient in the mix of factors leading to indifferent quality in industry, and to the non-utilisation of the formally trained in the positions suggested by their diplomas and degrees.

The last set of factors that relate to the whole discussion about science, technology and education is the question of foreign collaboration, industrial self-reliance, imports and protection. Unlike most countries in the South or North (with the possible exception of Russia and China) almost everything openly available for sale has been made in India, most of it on machines made in India, but a very high proportion of the electrical and mechanical items were originally made through a foreign collaboration and in many cases continue to be. Despite the high collaborative element, quality has remained a problem, as has the alleged continued dependence on foreign collaboration. It is further widely argued that 'there is hardly any science-based innovation in Indian industry' (Mohan op.cit., p. 6).

It can be seen that many of the same issues reappear in different arrangements in many of the areas centrally affecting science, technology and education. Some of these will be examined at greater depth, to give an indication of the many action research areas already covered, as well as some which are only beginning to attract serious attention:

1. Issues relating to the quality of science education in the formal sector.
2. Research accumulation on non-formal science education.
3. Utilization of science manpower.

1. Quality of Science Education in the Formal Sector

At one level, science is better established in the school system of many Indian states than is the case in other countries, including some in Europe. Science through environmental studies commences from Grade I; in the upper primary school, science is disaggregated into disciplines of physics, chemistry, biology and maths, and in the high school it remains compulsory until Grade X. The pattern will change somewhat from state to state, but the common thread is a strong science emphasis. Common also is a resistance on political grounds to devising one curriculum for stronger students, and one for the less academic. Professional educators may be attracted by differentiation, but not so the policy makers. Not surprisingly, the pass mark at school leaving certificate (SLC) is kept low (35% for maths and science subjects)
and even then rather less than 50% pass. Even in the highly educated (and some would say science-motivated) Kerala State some 340,000 are taking the SLC for the first time in any year, while a similar number are repeating.

A good deal is known in general about the examination-orientation of much Indian education, but how this affects particular subjects in science, and how far the backwash of SLC washes down the school system is not known. If there is a role for schools and colleges in producing this scientific temper, then presumably the teaching and learning environments for science become important. In resource-poor schools, without labs, there may be enough material for the teacher to demonstrate, even if no student can personally experiment. In other schools, completely without science materials, science subjects presumably become like maths, or history, taught entirely from the blackboard and textbook. Science is then learnt free of any practical experience. Even in better endowed schools, practicals in science are frequently squeezed out by the mass of theoretical material in the four science subjects.

The way that science is first acquired may seem a far cry from the larger questions of quality and innovativeness of industrial research but it is widely felt that if science education is to become a questioning attitude of mind, then it cannot easily be acquired in an education system that 'works in an atmosphere of conformity, non-questioning and obedience to authority'. It is for this reason that the Kerala Science Movement (Kerala Sastra Sahitya Parishat - KSSP) since 1971 has been taking science education into the schools with popular publications for different age groups, developing also several thousand science clubs and science corners, and promoting quiz competitions across the state. This voluntary association has a whole non-formal adult science education wing, as will be seen later, but in schools alone their impact has been presumably an important supplement to the regular curriculum. According to one teacher, his science club allows the children to ask questions which there is no time for in class. More important, the KSSP begins to put across to children the idea that science is not about formulae but about the application of knowledge to socio-economic problems.

Action and Research in Science Education

Apart from the KSSP, there have been a series of other bodies concerned with the improvement of science education in schools. Most of these accept that the explosion of new knowledge makes science education even more critical in schools; they are equally aware that science teaching generally is a parody of scientific

method. The emphasis is on more and more information correctly remembered, and ideally quoted from the textbooks. The very goal of promoting more science can thus be counter-productive. Whole sections of science knowledge are pushed further and further down the school system; concepts once taught in higher secondary are introduced in the primary school. The overloaded science syllabus then requires more traditional teaching and memorisation; it is difficult to justify time on experimentation and discovery. Hence the increasingly academic status of science in schools.

Different approaches to this oppressive teaching of science have been tried over the last 15 years, particularly during the 1970s and most have sought to reinstate the importance of discovery, observation, and independent judgement. Methodologies have included the use of kits, materials development, simplification of language, teacher orientation, national talent searches, science fairs, science centres, etc. In general, and perhaps inevitably, these activities of intervention and change have not been very carefully monitored; the process of adding up what has been learnt in a decade and more of experimentation is just beginning. It may be useful therefore to give some indications of where reflection upon action would be particularly valuable to the science community in India and to its counterparts in other countries.

Homi Bhabha Centre for Science Education

Tata Institute of Fundamental Research (TIFR). Spun off from TIFR in 1974, the Centre institutionalised several years of voluntary work by TIFR scientists in the Bombay Municipal school system. It was now possible to innovate and experiment in science education with the advantage of the TIFR research base. Understandably, this centre's work has been particularly concerned with the evaluation of its activities. Broadly, these have included a series of materials dealing with scientific problems raised by children, a set of concerns with simplifying the language of science, action research projects in providing discovery science to first generation learners in the rural area of Khiroda in Maharashtra, supplementary (Saturday) science for backward caste children from Bombay secondary schools. The last activity emphasises all the aspects that are missing in traditional science teaching and in pupils' attitudes, but beyond the problems of science education in general has the additional aim of giving the scheduled caste children the self confidence that they can succeed on merit. (One of the problems of the national government's policy of quotas and reservations for scheduled caste and scheduled tribe students, and the practice of allowing their entry to institutions at much lower grade scores than the other students is precisely the damage done to their self confidence.) By contrast the Homi Bhabha
centre wants to show that with the little supplementation (2/3 hours a week for 2 years), promising students can adopt a qualitatively different approach to learning. A second wave of students has now started the same 2 year programme and this time there is a control group of equally bright students not attending the centre. As anticipated, exposure to the Homi Bhabha 'system' does make a significant difference in their ordinary end of year exam scores, as well as to their attitudes to learning. Sceptics would argue that weekly contact with talented and committed research scientists, intent on question-raising and personal experimentation, is bound to have an impact, but how can it be generalised, how can it stop being the personal tuition experience of 30 selected students, and affect the schools from which they are drawn?

The centre can defend this action of experiment on a variety of grounds: it offers directly relevant policy research on equalising opportunities for scheduled caste students. It feeds directly into materials improvement for secondary school students. It also acts as an inhouse lab for examining processes of change. There is finally the possibility of continuing with a longitudinal study as the pupils leave school for higher education and the labour market.

The centre's wider concern with educational measures to counter social deprivation has led to their search for relatively low cost changes with high pay-off. One of the most attractive of these has been the production of an alternative set of science books for Marathi speakers from grades V to VII. Everything was held constant in the new texts - identical pictures, pagination, etc. to the government textbooks - but the language was dramatically simplified. Results were very encouraging; increases in mastery were evident, but decreases in the tendency to memorise passages, which so often affects student learning. Pupil and teacher participation also improved noticeably. Persuaded by these initial findings Bombay Municipal Corporation has encouraged a much more comprehensive trial of these simplified science texts.

The Homi Bhabha centre illustrates the range of different action research approaches to specific and general problems of improving science education. Materials development: but how to get them into schools. Discovery learning: but how to spread it beyond the range of the centre's influence. Moving from micro to macro has been attempted in the centre's Khiroda experiment where many of the centre's strategies were applied to a rural school network and further materials developed. From available documentation, this pilot extension of the centre's

strategies were applied to a rural school network and further materials developed. From available documentation, this pilot extension of the centre's methods seems to have worked out well between 1975 and 1977. The hope had been then to move to implementation on a large scale, and it was assumed that the personal contact as a means of communication would have to be replaced by modern technology of mass communication. This has not happened but we will notice later the potential of INSAT, the Indian satellite launched on April 10, 1982 as a possible follower of educational work under the 1975/6 SITE satellite program.

Science Education via Science Kit

A natural response to the lack of any equipment in most schools, and the consequent teaching of science as an entirely academic subject has been the development of science kits. The attraction of putting together a set of teaching aids in a portable container encouraged UNICEF and the National Council for Educational Research and Training (NCERT) from 1972 to promote India-wide kits and supporting guides. At the state level these have been made at relatively low cost (and ease) compared with many other Third World countries, and with some variations from state to state have found their way into primary schools. In Gujerat, for instance, a single kit box for St. I to St. IV went out to each of the state's 30,000 odd primary schools free, and for standards V, VI and VII, kit boxes were also developed and sold with differing degrees of state and district level support.

Kit boxes have not been given out in isolation from support activities. Indeed as part of their support to science education, UNICEF encouraged the establishment of science education units in the State Institutes of Education, and these in turn then ran a whole paraphernalia of courses - for science teachers in teacher training courses, for science inspectors at the district level, for lab assistants in colleges, and also kit box courses for primary school teachers themselves. No less than 250,000 of the latter had been exposed to those 3 day courses since 1972. But what is known of the impact of these state wide initiatives with science kits? Very little.

Preliminary inquiries in Gujerat State for instance reveal that kits on arriving in schools are entered on what is termed appropriately the Dead Stock Register. This is annually inspected, and should anything entered there be lost or broken, the procedure for removing it from the dead stock register must be initiated. The complexity of this bureaucratic procedure

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is such that few headmasters or teachers would willingly embark upon it (for articles lost costing more than 10 dollars, a whole committee has to be set up at the district level to make recommendations). In consequence, the kit box is better preserved locked and ready for inspection.

Kit boxes are a good example of the problems of curriculum innovation in sciences. Even if teachers are allowed to use them, they are only a partial answer to the problem of doing rather than learning science. At best, in a class of 40 or 50, the teacher may demonstrate something, but the pupils will not be much nearer to trying things out for themselves. So even if the obstacle of the dead stock register is overturned, there still remains the question of access and personal observation.

One of the most original attempts to work with kits and still make all pupils participate has been that associated with Hari Parameswaran and the Dynam Engineering Corporation of Bangalore. Ten years of trying to market low cost science kits to schools have brought the conviction that one kit per school is really not worth fighting for. It cannot be replaced, it cannot be shared, or experienced. After abortive attempts to market kits to 26,000 schools, and intensive interviews with all kinds of teachers, Parmeswaran now runs a 'teacher proof' use of science kits, in the sense that he has his own cadre of 26 teachers, who are dedicated experimental science teachers. In schools that agree to take the programme (at 5 rupees (50 cts)) per pupil per week, they will offer a weekly exposure during a double period of activity methods. For this price, all children will have access to cheap microscopes or whatever materials are necessary. The children's regular teacher will sit in, and ensure coordination between the live science programme and the regular syllabus.

There is as yet no evaluation of the programme, but the following points may be made. There is a built in advantage of the same agency organizing the teaching and producing the kits. It is possible to have rapid feedback from the schools and make modifications and explanations to the kits and literature that a purely commercial operation would not be interested in. Live science can be organized as a supplement to regular science teaching through an itinerant teacher corps (just as it can on Saturday afternoons at the Homi Bhabha Centre), but ultimately Parameswaran would need to retrain the regular science teachers if the scheme was to move beyond the schools currently involved. Finally, because of the cost factor, the present schools are largely those which, though overacademic, really need the supplementation the least. Poorer municipal schools cannot pay for the programme unless there is an official subsidy.

At the moment India has probably got a wider experience of different kinds of science kits than many other countries. In
addition to those mentioned, there is a science-kit-in-a-jar produced by Homi Bhabha and intended to make possible 30 basic experiments. At the other end of the market there is an electronics kit produced in Madras by the Committee on Science and Technology in Developing Countries (COSTED), and distributed to colleges and schools. It would be very timely to try and pull together what has been learnt in all these separate initiatives. Such has been the importance of UNICEF support that a separate analysis of its programme via NCERT should probably be undertaken. Equally, some detailed work needs to be undertaken that examines the interaction of teaching aids (such as kits) with the syllabus in ordinary primary and secondary schools. What kind of science understanding can there be in a 2 teacher village school, where the presence or absence of a science kit is the least of the school's problems? No sanitation, no electricity, little or no equipment, pyramidal drop-out pattern, etc. The inventiveness associated with kits is hard to visualise in the absence of much more basic infrastructures.

Community Science Centre, Ahmedabad

Kits and curriculum materials are two ways of attempting to bring science alive. We have noticed in their application to the school system a tension between 'adding-on' live science and installing it directly in the regular curriculum. Inevitably community science centres (and science museums) will be more on the enrichment-supplementation side of the spectrum. This is true of the CSC in Ahmedabad, one of India's most distinguished attempts to make discovery science influence local schools and the local community. Here too despite 16 years of very rich experience, there seems to be little comprehensive analysis of the lessons that have been learned. Yet some account of the diverse action in curriculum development, programmes for motivated students and teachers in lab work, and the more recent moves into non-formal education in rural areas would be very valuable. Of course much of this is available in annual reports, and in the occasional evaluation report of a particular activity, but a more synthetic account of a decade and a half's attempt to influence local schools, teachers and textbooks would be useful.

Each CSC unit has an institutional memory of trying certain approaches, working with students and teachers, both in a targeted and in an open house fashion. The same tension noted earlier inevitably appears: if promoting discovery approaches to science, do you narrow the discovery to illustrating particular problems in the actual syllabus of different grades, or do you develop non-syllabus specific exercises in observing, doing or questioning? Years of doing the latter may mean almost no dissemination of materials painstakingly developed. The former draws the centre into the narrowness of 'experiments for 5th graders'. This last is particularly problematic if the very basis of the 5th grade syllabus has little intellectual justification.
As with the Homi Bhabha Centre, part of the rationalisation for having small groups of St. V, VII, or post-graduate students utilising the CSC labs on a weekly basis must be to extract from those motivated students insights, problems and procedures that can be made the basis for new curricular materials, or new orientation courses for teachers. But what has been the experience with teachers? That only 3 out of a group will be sufficiently motivated to put CSC ideas into practice? What about supplementary materials for children? Will children really read booklets that are 100% or even 30% science information? What is the experience of Kerala's KSSP with its 35,000 circulation of EUREKA \(^6\) to children in primary school?

At least one member of CSC's staff, Jayashree Mehta, is worried about the tendency for action to push out reflection. Her three years of weekly visits to a rural school to teach and monitor science have led to major questions about the kind of concepts children can deal with in upper primary school. Is there perhaps a need for more basic research related to the reality of rural primary science? Perhaps partly in acknowledgement of the difficulty of making rapid progress with the formal school, the centre has diversified towards non-formal education, and is developing programmes in nutrition and health education for rural functionaries (with the help of CARE, and then USAID). Attractive as these new activities are, there is a continuing obligation to work with schools and colleges, and hence a need to consider what has proved possible and what not feasible amongst the demanding objectives set forth in 1966. For example

'I. to promote amongst students, teachers and the lay public (a) an understanding of fundamental concepts involved in the physical and biological sciences and mathematics, (b) the acquisition of scientific knowledge and insights as far as possible by the process of inquiry through experiments, AV media, and other means .... 4. to help make clear the social implications of science and technology.'

Kishore Bharati and Friends Rural Centre, Rasulia, Hoshangabad, Madhya Pradesh

These organizations have just completed a decade of action and research for the improvement of science education in middle schools. Faced with the familiar problems of memorised science, the increased quantum of information in textbooks, and the rural-urban school communication gap little appreciated by curriculum planners, the Hoshangabad Science Teaching Programme (HSTP) aimed to introduce discovery science in ordinary government middle schools. Starting with 16 schools in 1972, it encompassed all 220 middle schools in the district from 1978. It has

\(^6\) Science magazine for primary age children.
recently reflected on some of the major achievements and existing limitations of this programme. On the credit side, the workers feel that they have demonstrated that innovation is possible in government educational structures, and that joint voluntary agency-government initiatives are one way of implementing changes that neither might achieve on its own. A really large cadre of teachers can become committed to the new approach of teaching science by discovery methods, experiments and field trips. A crucial element in the mix has been the commitment of high quality research scientists from TIFR, IIT, UGC, Delhi University, and other universities and colleges in this science-based improvement of village education.

On the debit side, the major limitation 'concerns the attitude of the government. Barring some motivated government officials at senior and junior levels, the general government attitude has been of apathy and unconcern. The rigidity of administrative structures tends to reduce creative efforts to naught and considerable inputs are required to overcome such barriers'. The point is made very forcibly that counter-balancing the bureaucratic structures of government really requires very major capabilities and human resources on the side of any voluntary agency. This is an issue that will be encountered again when the problem of taking 'science' to the community is examined.

For the moment, one of the most significant outcomes of Kishore Bharati's reflection on its past experience is the decision to explore further areas of expansion - to carry the science programme beyond the district to the state, and to other states if there is interest. It is also apparent that there is now a concern about transferring the specifically science education methods to all other subjects and school levels. This is itself an interesting comment, for science has thus far attracted much more innovatory attention than other subjects.

The vehicle for extending the scope of the last 10 years' work is to be an Institute for Educational Research and Innovative Action which will have a coordination and planning centre in Bhopal and four field centres. It expects to draw its support from three sources, state government, central government, and private agencies, and for the first 3 years they have worked out a rather demanding programme. A major task to facilitate this expansion programme is 'a comprehensive manual in which our experiences, methodology, working methods, examination method, etc. are distilled'. Such an analysis


8 Ibid., p. 13.
would not only be very timely for focussing attention on the science education system; it would also be concerned to pinpoint processes that allow the diffusion of micro experimental schemes into macro level action programmes. The transition from micro to macro has been the reef on which most innovative action has foundered.

Creating a few model schools and universities (Sevagram and Shantiniketan come to mind easily) is in the wider context quite meaningless as the beneficiary populace is not even a countable fraction.⁹

The above four institutions (Homi Bhabh, CSC, Parameswaran's science kits, and HSTP) were selected in no particularly scientific manner to illustrate something of the state of research and action in science education over the last decade and more. Doubtless, it would have been just as easy to select other agencies,¹⁰ and reach some similar conclusions about the current climate of science research as it impacts on the formal system.

We have noted a strong and growing interest in adding up what has been learnt in this decade, and also other areas where it is more difficult to pinpoint research-based conclusions. A partial listing of areas that would benefit from further review and research attention would include:

1 Qualitative studies on how science is actually taught in primary and secondary schools and colleges. It is widely assumed that the present methods are a travesty, and that one should proceed forthwith to innovate in the various ways mentioned above. It would, however, be very useful to examine in more depth what is actually achieved in three years of upper primary science (for those who then drop out) and the further three years of secondary science (for those who continue). How much 'scientific temper' is transmitted by non-experimental, rote learning?

ii How much significance should be attached to examination scores in science and maths as indications of learning? The rote learning system, with its precise notes, exam guides from the bazaar, supplemented by very large amounts of homework (and occasional private tuitions) does presumably have some positive aspects. Is a poor teacher better with the old methods or the new? Is it possible to argue that the old system is more 'teacher-proof' than the new? Given the importance attached to

⁹Ibid., p. 8.
¹⁰For a listing of some of these, see Proceedings of the Conference on Science Education, op. cit.
homework and frequent tests in many other studies of student achievement, there are perhaps some aspects of the existing science teaching that need closer analysis. It is worth noting that one of the researchers in Kishore Bharati has made a related point about the eventual examination results of the HSTP schools:

After the middle school stage these students are not required to employ the qualities and skills which they are supposed to have acquired through the discovery method. Hence it would be expected that, in a traditional examination system, the performance of the students from the schools under the programme would be indistinguishable from that of students from schools where science is taught by the traditional method. An evaluation made recently confirms this hypothesis.\(^{11}\)

iii The larger question raised by these radically different teaching styles concerns their enduring effects. Examination scores are relatively meaningless when it comes to measures of creativity and independent thinking. It would be entirely possible for students taught in a discovery mode to do less well in formal examinations than ordinary students (the exams after all are a very close reflection of the teaching methods of the schools). The question then becomes what difference creative teaching makes in situations other than the examination? e.g. in technical work, in research activity, or in agriculture. Is there any link to the alleged lack of creativity of highly trained scientific manpower? What are the larger term consequences of exposure to the Homi Bhabha centre's supplementation, or to Hoshangabad? Is it worth conducting some analysis of the post-school consequences of really good science education? Although good education is intrinsically valuable, it may be worth looking in addition at the range of expectations that are assumed to flow from it. Sorting out the variety of these more or less idealistic expectations is itself important, for there is always a danger, as H.N. Sethna has warned, of believing 'that science can achieve anything and solve any problem'.\(^{12}\)

iv A closely related issue concerns the quality of university-level trained science students. India has an enormous


production of these, going to polytechnics, science colleges, engineering and medical schools. Teaching styles may not be that different in college than what has been described for schools, but again very little seems to be known with any certainty about the skills and attitudes with which people emerge from science colleges. Sethna of the Atomic Energy Commission has asked 'what must be the quality of those third class (science) graduates, if we are finding the vast majority of even the first classes so pitifully ignorant in their subjects?'

Science kits have been picked out in this paper because they are an indicator of a whole range of responses to what is seen as over-academic science teaching. But broader issues about the nature of educational aid and innovation strategies are raised by this subject. Kits are not necessarily synonymous with creativity and experimentation; they can open up inquiry or close it off. Again, kits can symbolise a more democratised access to experimentation (Parameswaran) or they can be as inert as any article too precise to use. So analysis of their utilisation is in order, to supplement an understanding of the ways science is learnt.

2. Science to the Community: Non-Formal Science Education

Although it is a mistake too rigidly to separate non-formal science education from the issues discussed in the last section relating to formal sector science, the context and problems are sufficiently different that it is organizationally easier to draw some distinction between the two. However a number of agencies (including CSC Ahmedabad and Kishore Bharati) operate in both sectors, and are aware of the necessary connection between the two spheres of action. Given the drop out rate of 70% in primary education, and the very small proportion continuing beyond St. VIII, Kishore Bharati have noted the contradiction between the objective of hoping to influence a majority of the age group and working in the school system. 'Exploring innovations, methodologies and structures for such a large deprived community cannot be ignored. It has been our experience that such non-formal work not only has the potential of benefitting drop outs but also contributes to the enrichment of an environment-based school curriculum and teaching methodology'.

The major conceptual distinction between formal and non-formal sector work is that the former, to have any influence at all, has to pay attention to school definitions of science. However creative,

13 Ibid., p. 21.
14 Evolving Systems, op. cit., p. 15.
formal science education needs to relate at some point to the
determined syllabuses. The starting point has to be the
existing definitions of science knowledge even if the intention
is to expand these, subvert them, supplement or redefine them.
In carrying science to the community, on the other hand, the
enemy is much less apparent, and, accordingly, approaches are
much more divergent.

One of the difficulties about analysing non-formal 'science'
education is that almost every type of rural development activity
can loosely be seen as the application of scientific knowledge to
rural areas. Village level health, agricultural extension,
nutrition, contraceptive programmes, water development and
energy experiments, all seem candidates for inclusion. To
reduce the universe somewhat, it may be appropriate to look
particularly at those initiatives which have had (a) a pronounced
scientific research base at the heart of their activities,
(b) have been investigating new ways of transferring science
knowledge and new technologies to rural communities. It will
be noted that the mechanisms for transfer frequently involve a
participatory dialogue between the scientists and the village
communities. This means, in turn, that several of these
initiatives partake to some extent of the wider culture of popular
participation and consciousness raising that informs so much of
the voluntary agency world, either in theory or in practice.

(a) Elite Science and Rural Development

A feature of many of the most science-based endeavours is
that they emanate from institutions of elite science, such as
the Indian Institute of Technology and the Indian Institutes
of Management (IIM). These institutes, as we have mentioned,
take students who have successfully survived one of the toughest
examination marathons in the world, and are only too sensitive
to sniping about their isolation and their failure to address
themselves to research relevant to rural India. It is perhaps
not surprising that small groups of faculty have over the last
decade applied their scientific training to rural development
and problems of ordinary education.

The example of the Homi Bhabha Centre for Science Education
has already been referred to in relation to the Tata Institute
for Fundamental Research in Bombay. That initiative was
primarily concerned with formal schools, but other TIFR faculty
have attached themselves to rural projects. In the case of IIM
Ahmedabad, there has for seven years been a rural development
project in Jawaja, a block located in the state of Rajasthan.
IIT Madras has run a Centre for Rural Development since 1976,
and the Indian Institute of Science in Bangalore has since 1974
had a call for the Application of Science and Technology to
Rural Areas (ASTRA). Finally, the Space Applications Centre
(SAC), a part of the Indian Space Research Organization, has
long had an interest in the social impact of both scientific and other programmes sent to a particular project area.

The Jawaja Project, Rajasthan

The aim of this project was to raise the technological and productive base of certain villages using a technology and pedagogy appropriate to the area, and engineering the changes in ways that increased local autonomy. We have seen earlier that making a small dent on the formal school system can require a major and sustained application of pressure from the change agent. This seems to be even more the case with even small non-formal intervention in the rural areas. One of the most remarkable aspects of the Jawaja project has been the detailed documentation by letters from the project team to one of the key officials in the Jawaja area. These letters lay bare the extraordinary range of contacts that the project leader, Ravi Matthai, brought to bear in the process of investigating new technologies, new sources of finance, and new markets for the produce of the weavers, spinners, leather workers and tomato growers. Agencies at the block, district, state and natural level were called upon for technical advice, support, markets. Of the multitude of authorities asked for technical advice in the early stages of the project, there are mentioned: Central Sheep and Wool Research Institute, Central Glass and Ceramics Research Institute, Forest Research Institute, Central Cottage Industries Council, National Dairy Development Board, National Institute of Design, Weavers Service Centre, Council for Scientific and Industrial Research, Rajasthan Small Industries Corporation. Many of these were brought into a continuous relation with the project, as was the Bank of Baroda for loans. Constant pressure and information exchange with the local administrative structures was also an essential component.

The list of high level bodies is not intended to suggest that this was an exercise in rural development by one powerful institution (IIMA) pulling strings, for there was an incalculably important input from the unpaid Independent Volunteers, and very genuine attempts to relate the technical advice to very specific village suggestions for new products. Rather, the importance of 'The Jawaja Letters' (and the longer narrative account of the project) is attributable to the honesty of analysis of this intervention project. For anyone thinking that improving the design of the weavers and leather workers, and arranging small bank loans is something that can be rapidly initiated, and allow the project team to move on elsewhere, these letters are compulsory reading. There turn out to be almost endless ripples of obligation and accountability that spread out from the few

initial changes in design, and in tanning technology; there is also a constant awareness of the trade-offs between fixing things and increased dependency.

There is always a tendency in looking at a project of this sort to ask what is generalisable, what is replicable. Given the hope that the scheme could illustrate an alternative learning system (hence the use of the term 'Rural University'), it is appropriate to try and distill the essence of these 6 years of negotiated technological change. In such a skill-rich environment, is the new technology the least of the problems? Are the real learning problems the ones associated with sales, marketing, and the management of rivalry and competition? Beyond the historical detail of these 'Rural University' letters, it would certainly be valuable to have a terse commentary on the lessons of negotiating the entrance of new technology. They certainly seem to be as complex and political as any major technology transfer at the international level.

Centre for Rural Development, IIT, Madras

At the other end of the scale from open-ended negotiation with existing village skills is the CRD, run by the IIT just at the boundary of Madras city. In contrast to Jawaja's decentralised groups, CRD is the expression on a single site of the concept of interlinking a series of available technologies and producing a commercially viable model of a miniature industrial estate. Unlike many government schemes which don't have to show a profit, the CRD was organized around a straightforward bank loan of $6 million dollars, and the expectation that 300 new jobs could be found for the nearby villagers. The emphasis is on wage employment rather than self employment, and on modern technology rather than improved village technologies.

While Jawaja's technological changes have been principally related to one or two new woven products from new looms, and new tanning technology for new product markets, CRD, freed from the need to negotiate and improve on village technology, had within two years produced an entire integrated system: new construction technologies, biogas, energy, paper making, fish farming, rice milling, dairy, agriculture, forestry, water development, electronics, screen printing and plastics, soap making, garments, printing press, engineering products and carpentry.

Taken one by one, each of these activities is very common in any large town in India (with the possible exception of fish farming). The IIT's contribution has been their combination into a model micro-industrial estate. Like the IIM and Jawaja, the IIT can offer access to some protected markets and materials (scrap paper, printing orders, etc.). It has also been able to
rely on IIT graduates for its chief techno-economic officers in
charge of the three main divisions of civil, mechanical and
agricultural engineering.

It presents therefore a polar opposite to the Jawaja style.
Both are concerned with new technology, higher productivity,
job creation, and eventual local control of the new processes.
The CRD has probably attached a larger number of villagers (300)
than the total number of weavers, spinners and leather workers
related to Jawaja. The general differences in style, however,
are so great that it would be instructive to have a comparative
critique of their impact on those they have sought to serve.

Space Applications Centre, ISRO

During the year of the Satellite Instructional Television
Experiment (SITE) 1975/6, TV programmes were beamed to schools
as well as broader messages to adults on agriculture, nutrition,
family planning and animal husbandry. In fact the bulk of
adult audience had a much larger proportion of basic entertainment,
in addition to the subjects mentioned above. It was found in
the school broadcasts that merely altering the medium of science
education did not make much difference to understanding or school
achievement. A TV science programme, like a science kit, does
not have a life of its own, but is highly dependent upon
intelligent pre and post telecast discussion by teachers. On
the whole these pre and post-sessions did not take place,
despite teachers being given TV orientation to utilising the
programme to the full.

As far as broadcasting to adult viewers is concerned, SITE
provided an important learning experience for SAC. It had
become clear that the software was much more difficult to plan
than the hardware. Beaming science-based information in
agriculture, nutrition or health told one very little about the
nature of the programmes' impact. Nor did a once-only summative
evaluation indicate the complexity of the development communication
process. Indeed a major research outcome of the SITE year was
the recognition that both quantitative and qualitative methods
of evaluation would need to be followed, accompanied by an indepth
anthropological study of the process at the village level if
social science was to profit from this novel communication.

In the years that have followed the end of the first satellite
transmission, SAC has continued to beam its own TV programmes to
part of Kheda district in Gujerat, but there has been a significant
shift toward a decentralised and participatory communication
process. As an analogue to the more participatory attempts to
teach science discussed above, SAC began to explore with villager
cooperation some of the major social and economic problems of
rural life, especially for the lower castes. Direct villager
involvement with social scientists and communication scientists
in the production of TV programmes raised awareness of problems with an immediacy not easily found in other media. For example, filming a politician preaching against caste, asking for water and refusing to accept it from a harijan, then filming villagers discussing the rights and wrongs of the situation turns out to be a very potent message if beamed back to the very villages experiencing this. So potent in fact that there are real dangers and moral dilemmas posed in broadcasting these films.

The SAC example may seem somewhat remote from the other illustrations of taking science to the people; it is different principally in having moved from a centralised transfer of science-based information to a decentralised participatory process. In the interim, faith in the power of science information by itself to make an impact has been altered towards a social science appreciation of the conditions of impact. As INSAT is in position from mid August 1982, SAC's experience in transmitting both science and social science to villages will be vitally important. What they have learnt from both formal and non-formal science programming should be available for this next round. But to what extent have the SITE lessons been more widely absorbed, especially SAC's view that 'the planning for software aspects of communication technologies must start many years prior to the planning of hardware aspects'?16

Application of Science and Technology to Rural Areas (ASTRA), Indian Institute of Science, Bangalore

The last of the initiatives emanating from the most prestigious science and technology management institutions is ASTRA.17 It was not possible to visit ASTRA's staff or its extension centre in the rural areas. But there exist several accounts of the Centre's work, which allow one to see that ASTRA is much the most 'technological' of those we have treated so far. Its role is primarily to work on the generation of new technologies for villages, and to try these out in the extension centre, as far as possible in active collaboration with villagers. Dr. Amulya Reddy, the ASTRA director, is aware of all the dangers of scientists generating appropriate technologies in complete isolation from village reactions and rural conditions. He is also conscious that the status of scientific work for villages will tend to be downgraded in a high powered science institution; hence he has had to argue that simple products and processes require sophisticated thinking and research. Indeed 'efforts to generate appropriate rural technologies necessarily require

16E.V. Chitnis quoted in Binod Agrawal, SITE Social Evaluation Results, Experiences and Implications, Space Applications Centre, Ahmedabad, 1981, p. 60.

17Beyond those mentioned, there are rural activities in other IITs and IIMs.
more, not less, simultaneous emphasis on basic research and fundamental science',\textsuperscript{18} since there is no beaten track from which to start.

There are intriguing differences between the ASTRA approach and that of CRD in Madras. The latter spent much less effort on the generation of intermediate technologies, but innovated in the inter-linking of a series of broadly modern technologies. ASTRA has felt it important to try and 'expose the people to a wider range of technological options instead of the two-option Hobson's choice with which they are currently confronted - either suboptimal traditional technologies or far-too-expensive "modern" technologies'.\textsuperscript{19} There are major differences also in the extent of negotiation and popular participation. Obviously CRD's operation that needed rapidly to become commercially viable acted under greater constraints than that of ASTRA.

ASTRA has sought to reflect on what they have learnt from the model they have applied since 1974.\textsuperscript{20} In particular they have analysed the structural connections between the science training system with its set of values mirrored from developed countries and the need to generate and diffuse new technologies for rural areas. They see the patterns of technological capability distorted towards the problems preoccupying the developed countries. This in turn is reinforced by the foreign graduate training of the best science students.

No wonder that most foreign returned scientists and engineers spend the bulk of their remaining active professional lives continuing the themes of their foreign researches even though the stark reality outside their laboratories and workshop is clamouring for a local commitment and a native orientation.\textsuperscript{21}

In this situation, it would seem that indigenous technological capability is neither being developed adequately to modify or challenge western industrial technology, nor to develop a wide range of newer small scale rural technologies. With the orientation of existing scientific research firmly fixed on the urban industrial sector, one wonders what progress has been made in institutionalising the rural commitment of scientists. Reddy

\textsuperscript{19}Ibid., p. 16.
\textsuperscript{21}Reddy et al., op.cit., p. 137.
correctly looks to reorientation of the existing educational infrastructure rather than the creation of a few institutes for rural technology; but one wonders what progress has been made over the last decade in research reorientation towards rural requirements. Has the pattern of annual scientific awards at all altered to recognise the kind of work ASTRA has been promoting? Have the various calls and individuals dedicated to these rural technologies become regular departments or faculties of universities? Is this thrust becoming part of the regular academic programme, and 'not an extra-curricular activity of a few scientists/engineers with an urge for social work'? Some indications of what might be expected in such a reorientation have been sketched out by Professor B.M. Udgaonkar of TIFR, but there still seems to be a tendency for the rural technology cells (or other initiatives) to be quite on the periphery of the prestigious institutions which house them. It would be useful to analyse to what extent there have been significant changes in research emphasis, and what are the limitations that may be expected in any such redirection of science towards community service. Even if most major institutions now have some sort of window on rural development, what kind of influence have these had on the regular departments and student participation? To use Kishore Bharati's term, what sort of 'dent' has been made in mainstream science by the presence of the rural scientific extension centres? Any analysis of progress and achievements these last ten years would have to pay attention not only to the few institutions mentioned here, but also to assessing the Karimmagar experiment in Andhra Pradesh, which was the rural experiment and demonstration centre of the Council for Scientific and Industrial Research (CSIR), and several other initiatives.

In this section on the rural aspect of certain prestigious science institutions, it would also be worth noting the role of the Committee on Science and Technology in Developing Countries (COSTED). With its secretariat in India, at Madras IIT, and its president the vice chancellor of Nehru University, it has had a particularly close liaison with some institutions mentioned above. Indeed, its scientific secretary, S. Radhakrishna, is also the chairman of the Centre for Rural Development at IIT Madras.

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24 For more detail on CSIR's Karimmagar project, see Hari Narain, 'Karimmagar-CSIR's Experiment in Integrated Rural Development', in Radhakrishna (ed.), op.cit., pp. 106-120.
25 Its president, Y. Nayudamma is now a governor of IDRC.
In many of these various exercises of what we have termed elite science institutions, there is a need to take stock, and look across institutions at what has been learnt in common about different methodologies, communication strategies, ways of negotiating on technologies with villagers.

(b) NGO Science for Communities

Beyond the several attempts by renowned institutions to relate to rural communities or rural technologies, there is a wide scatter of non-government agencies committed to similar sounding goals. Some of these are national, some state-wide, some very localised. Although some are linked to political parties, many are explicitly delinked and yet are working on the major issues of social transformation with particular communities. For many, the potential of science is strongly affirmed, but they are disenchanted with the official recipes and structures for 'delivering' science. D.L. Sheth, who has been studying the new politics of these NGOs has commented:

... the educational and professional establishment are fast losing their credibility as instruments of modernization. The magic of the "science of management" is fading away. What once looked like problems solvable by proper application of social science knowledge and modern management now appears to lie beyond their ken ....

All the programmes and activities of the established institutions now look lustreless; they hold no promise of solving any real problems of the poor. Now the university graduates going out to work with the people acutely feel the need to delearn what they have learnt in these institutions.26

As it was not possible to spend time with any of these groups, reliance must be placed on written sources. This is seldom satisfactory, since many of the groups do not have the time or inclination to commit much to paper. Hence there is a natural tendency to overemphasise the significance of the more formal institutions which have the infrastructure to produce annual reports, evaluations and conference papers. By contrast, the process of documenting science to the people via NGOs is much less straightforward.

Two exceptions to this relative dearth of written material are Kishore Bharati and KSSP (the Kerala Science Movement). Both of these, we noted, had a concern with formal science in schools, but have also made major contributions to understanding the role of science in relation to rural communities. Useful

recent documentation on what they have learnt in the process of carrying science to communities is available in two key statements:

1. *Science for Social Revolution* (Kerala Sastra Sahitya Parishat, 1980) and


These documents are valuable summaries of work during the 1970s in Kerala and Madhya Pradesh, but for our present purposes they also serve to differentiate science-based rural development from many other varieties of action programme in rural areas. In examining Kishore Bharati's attempts to apply science and technology, Anil Sadgopal draws a distinction between observation of reality in the social science and in the natural sciences. Although observation, data collection and inference are common to both, experience with Kishore Bharati had shown how frequently in social science the aspect of reality perceived was related to one's cultural and economic background. Observation of the 'needs' of rural people differed widely depending on the nature of analyst, whether aid agency, government department, rich farmer or poor. 'In contrast, the process of observing and analysing reality in the natural sciences is dependent only on the scientific skills of the worker, and not on his or her class background'.

This ability to observe and conduct analysis in the natural sciences is not something that is the prerogative of the educated; the poor can be trained to it. Indeed the method of science can be spread amongst the poor so that they can perceive their own socio-political reality, and can plan their own development 'on the basis of reliable data and logical thinking'. However, the problem in popularising scientific method, or scientific temper seems to be two-fold. As far as those currently applying science to rural areas is concerned, the objectivity mentioned above soon vanishes:

The moment one begins to relate science to the problems of society (for example, the case of technology) the class affiliations and the vested interests of the worker begin to influence his or her objectivity in a manner similar ... to the social sciences.

Sadgopal has no shortage of illustrations of how the process of applying technology - whether wells, improved cattle, improved

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28 Ibid.
potting, science aids - has reinforced inequality; the scientific temper is quickly overlaid by the class interests of those mediating and distributing the technology. On the other hand, the scientific method is still very inadequately understood by the poor, and where it exists potentially, it is constantly being undermined by lack of information, fatalism, fear of reprisals, and inability to generalise and abstract. These continually interfere with accepting the logic of scientific analysis, just as other forces distort the application of science and technology through the official channels and agencies. There is thus a kind of dialectic that needs to operate continually between political or other impact upon the barriers to self-perception and the process of education in scientific methods. The dynamic relationship between scientific method and incremental political changes is at the heart of Kishore Bharati’s experience:

The educational work of spreading the scientific method does not progress as long as such barriers continue to exist but can be started all over again once these barriers have been broken by mechanisms which are beyond the realm of science.30

The 'syllabus' of non-formal education (science for rural communities) is thus a good deal more complex than the inquiry-based science teaching programme in schools. The former proceeds by fits and starts. If 'inquiry' is the active ingredient in the school science scheme, political action or insight even on a micro scale, can be its equivalent in the non-formal, community science. For example, seeing a common village scene of discrimination against harijans heightened by a SAC telecast. The parallelism between the formal and non-formal sides of Kishore Bharati has been touched on earlier, but put another way, it could be said that science via the inquiry method produces a challenge to traditional methods, and hopefully produces a more creative worker, while amongst the peasantry the hope is that scientific methods can become part of a people's way of thinking, and can in turn challenge the vested interests in the village and countryside.

The latter may sound rather idealistic, but certainly it would be interesting to have documentation on how this non-formal science 'syllabus' has worked out in practice with some of the communities in the vicinity. Presumably one of the moral dilemmas central to this pedagogy is how to handle the awareness raising aspect, without which the cognitive work on new science-based knowledge and method may sometimes lie inert.

It is not possible here to go into the methodologies of the many other science movements such as the Centre of Science for

30 Ibid., p. 19.
Villages in Wardha, the Society of Young Scientists, the initiatives of Dr. Shankar Chakravarty in West Bengal, the Science Education Centre in Attara, Uttar Pradesh. Nor will we go further into the relatively well documented KSSP in Kerala, beyond stressing that its action research component has become increasingly important in mobilising local and state wide opinion against the misapplication of technology in development schemes. What would be useful, however, would be to have a review of the different characteristics of 'science' within these, and the range of ways that scientific knowledge and method is related to popular participation and community transformation.

3. Acquisition and Utilization of Science and Technology in Industry: Formal and Non-Formal Patterns

Our concentration thus far has been very much on problems connected with the learning of science in schools, and colleges, as well as non-formally in villages. There is no doubt that there is concern also about the acquisition and utilisation of science and technology in industry, even though we have noted a widespread feeling that the science system is already too much oriented to industry.

One set of issues seems to relate to the disjunctions between scientific research and industrial adoption. Despite research being preoccupied with industry and commerce (rather than rural development), it still seems to appear irrelevant. Allegedly the research and the prototypes produced in many of the national institutions are remote from possible applications. It is not infrequently that the National Institute of this or the National Laboratory of that is being chastised for having virtually none of its products or prototypes adopted. Various reasons for the malaise are often suggested in the intellectual weeklies, in readers' letters, and in conversations. They tend to mention the bureaucratic structures of the institutions, the lack of personal and structural incentives to creativity, a lack of commitment to productivity, authoritarianism by institutional heads, and the derivative nature of the research done in Indian labs. The following perception is widely shared:

The practice of science in India is imitative and not innovative. Our scientists add to the data that no more than confirm the conclusions reached elsewhere. The local needs and resources are seldom the subject of Indian research. This is why we neither have Indian science nor Indian technology. Originality and inventiveness are derived and if pursued, in spite of derision, punished. The science administration is by and large unscientific. (The Hindu, July 8)982).

On the other hand, the official view of the Council of Scientific and Industrial Research (CSIR) with its 35 national laboratories, 71 extension centres and regional labs, is that it renders wide ranging services to support the national infrastructure in the achievement of self reliance. It sees itself as one of the largest state-supported R & D organizations in the world. No less than 4500 scientists are on roll, supported by 14,000 staff. The total number of processes released to industry up to 1981 was 1293 of which 571 are reportedly in production.32

However that may be, there seem to emerge constant reports about the conditions under which scientists have to work, their subjugation by the bureaucracy, the failure of their professional associations to support them or criticise them when appropriate,33 and, of course, running through it all, the alleged irrelevance of their research endeavours.

In this atmosphere, it is not surprising that some scholars should have tried to examine this research culture more closely, and ask questions about the truth of the caricature. One of these, Dinesh Mohan, has even tried to get some sense of where Indian science stands internationally, by looking at their standing against a series of rough and ready benchmarks of quality (international and national awards, appearance in most cited articles, faculty members of highly rated universities etc. etc.).34 The outcome is very tentative but both at home and abroad it seems that Indian scientists are not making their presence felt in the innovative or frontier areas of research and development.

For our present purposes, what is of interest is whether there is any particular reason to believe that the educational system itself has any part to play in the production of this research malaise. We have already noted the extraordinary concentration on reproducing exactly the knowledge given by text book and teacher, at every level of education, and we have also paid some attention to the agencies trying to instill discovery and creativity into primary and middle school. Doubtless, part of their rationale for promoting discovery science in school is their awareness of bureaucratised research at the post-college stage. Mohan himself, teaching in an IIT, is clear that early education is quite largely responsible. Some of this is attributable to the perpetuation of a colonial

education discouraging Indian innovation, some to the uncritical
teaching and learning style of present institutions, and some
(perhaps a great deal) due to the continuation of English language,
dividing India still into two nations:

The persistence of English as the language of Indian
science and technology automatically precludes the
participation of the overwhelming majority of India's
population in the scientific culture. Most of those
who still manage to engage in scientific activity do
so at arm's length and at an enormous cost. They are
forced to conceptualize and be creative in an alien
medium.\textsuperscript{35}

Obviously, there are no single factor explanations of these
features of the research culture. In the academic institutions
and government research laboratories the role of funding is
critical in addition to all the other factors mentioned. While
in industry itself, the extent to which research is at a premium
will closely relate to whether the company is reproducing
technology through collaboration, or developing new products on
its own. There may, however, be some merit in suggesting that
the specifically educational contribution to this problem be
examined in a little more depth.

It is possible that this issue has already been over-examined,
but there may be room for some of the following:

- A review of studies that have analysed the higher
  educational environment in which the research culture
  is nurtured.

- Qualitative studies of university science environments,
  and of particular research labs.

- Analysis of what studies have been done on the role of
  research in the private sector.

This last is particularly crucial for a better understanding
of research potential and its utilisation in industry. One
relatively common view is that there too, like the government
sector, there is hardly any science-based innovation. It is
argued that industrialists want a foreign collaboration for
even the simplest product.\textsuperscript{36} More specifically it has been
said of the pharmaceutical sector that despite claims of
significant inhouse R & D in India, not a single drug has been
discovered by any of the main centres.

A large part of the so called research is actually
quality control, market studies, clinical trials and

\textsuperscript{35}Ibid.
\textsuperscript{36}Ibid.
other similar activities .... None of the projects carried out address themselves to the basic problems of major illnesses like tuberculosis, leprosy, malaria, diphtheria, gastro-enteritis, etc.

Since R & D expenses in India are relatively low, the facilities of some of these laboratories are utilised to carry out basic research required by their parent companies who themselves carry out the intermediate and penultimate stages, keeping the Indian subsidiary in the dark.

The terms in which these discussions are carried on may seem somewhat overdrawn, but they indicate a little of the sensitivities and concerns about creativity, innovation and nationalism that emerge whenever the role of research in industry is discussed. They are part also of a wider debate relating to indigenous technological capability (ITC) and this in turn has sought to examine the historical differences between Indian and other Asian industrial nations (notably Japan) in respect of research and innovation.

Scientific research and industrial innovation, however, is only one aspect of the many possible relationships between science, technology and education in industry. Doubtless, case studies of particular firms would be valuable, especially if attention is paid to the varieties of ways in which innovation can express itself apart from major technical advances. But there are many other facets of ST and E that seem equally important.

The changing pattern of utilisation of technologically trained manpower is an area that seems crucial, and this in turn has a very close and dynamic relationship with the planning of different categories of higher technological education. There has, for example, until recently been a tradition of limiting rather strictly the expansion of engineering colleges, and above them the Indian Institutes of Technology. This has then offered a certain premium and protection to the engineer over other forms of technical and technologically trained manpower. One consequence of this special treatment for engineering colleges has been that much more attention has been paid to evidence of unemployed engineering graduates than to other categories of science graduate. Indeed, it could be said that very much less interest attaches to the notion of unemployed science graduates than to engineers.

37 M.S. Iyengar, 'The Status of Research and Development in the Private Sector', mimeo, Department of Mechanical Engineering, IIT, Delhi, p. 9.

38 See papers by Ashok Desai, Ron Dore and Tom Eisemon, at Conference on ITC, Centre of African Studies, Edinburgh University.
These processes of limiting seats for certain vocations and being relatively flexible with the expansion of science colleges produces a hierarchy of preferences within the education and training system. This sets up very powerful pressures to expand those sectors most protected by limitation of seats. Hence, in different states the emergence of private engineering colleges, particularly in Karnataka, Andhra Pradesh and Bihar.\(^3\)

As the tussle goes on between limitation and expansion in the few protected islands of India's sea of higher education, it is important to look at a double set of influences: the backwash on schools and the 'forewash' towards industry. Science continues to be critical in schools as only the highest possible exam marks will secure a place in medical or engineering college. Once that selection has taken place, however, pure science becomes much less important; indeed entry to polytechnics is more favoured than the ordinary range of science colleges. The status differences then amongst the three groups (engineering degree holders, engineering diploma holders, and science graduates) are much wider than would be anticipated, and have important consequences for the pursuit of science knowledge in the different institutions.

On the industrial side, the utilisation of these and other categories of trained manpower is presumably a good deal more untidy. Employers are aware that the brightest students in the school system have entered engineering colleges (including IITs which are basically engineering colleges). They may then be tempted to recruit them as managers as much as for their engineering skills. This position of engineering as the flagship of the science training system probably produces some distinctive patterns of industrial organization. First, there are likely to be a larger group of top managers with engineering backgrounds than in many other countries. No bad thing, it would be thought, compared with systems where management has a non-technical background. However, the very status and aspirations of the engineer, at the peak of the education system, may lead to his under-utilisation in the sectors for which he was prepared. This tendency could well be compounded by the existence of the large informally trained labour power:

In many industries, both large and medium scale, there has not been full utilisation of the products of the engineering education and training system. Partly on account of economic reasons, and partly because of a failure to upgrade technology, the engineering graduates and diploma holders have not been fully utilised. Many industries continue to use a large number of unqualified technicians and even engineering supervisors. The private sector particularly finds that experienced

\(^3\)The Hindu, July 18, 1982.
workers, mainly those who enter the factories at lower levels, are better at handling production than fresh diploma and degree holders; and therefore it continues to use a large number of 'practicals'.

It would be dangerous to generalise before looking in much more detail at the utilisation of different grades of manpower in different kinds of firms. For example, one firm that was visited had no less than 60 engineering graduates, 60 engineering diploma holders, and a small number of science graduates. A third of the whole workforce was derived from these three groups. Significantly, this enterprise was making a moped without any foreign collaboration. Doubtless, very different mixes appear in other kinds of firms, and these will be different again from the more standardised ratios of engineers to other categories in the railways and public sector concerns.

Overall, however, the widespread availability of both formally and informally trained manpower has meant that firms could increasingly draw upon more educated, science-trained candidates if they so desired. To the extent that firms do use these, it would be interesting to know what difference to quality or productivity it really makes to employ a virtually graduate and school-leaver workforce. It is often assumed that an oversupply of ordinary science and arts graduates is wasted if they work in firms that do not really require their level of knowledge and expertise. But very little work has been done on the phenomenon of 'over-education'.

It is possible that the real merit of having an over-supply of various categories of scientifically educated worker is their capacity to master rapidly the techniques of production, and in due course set up on their own. One's impression is that this moving into self-employment happens very widely. Many factors fuel this, but the ease with which an entrepreneur can find the talent available is clearly an important one. Among questions that could be addressed in this situation would be:

- Amongst communities (e.g. Gujeratis and Sindis) that have a long tradition of business enterprise, does it really matter that their formal education is such as has been described earlier? Does examination-oriented, non-discovery schooling really make for lack of initiative and creativity? Home influences perhaps continue to be more powerful than the school and encourage creativity and enterprise that the school has not wiped out.

- Amongst groups where there is little home stimulation towards independent thinking, and new work experiences,

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then the school has an enormous gap to close. It will take all the power of Hoshangabad science to compensate for the home environment.

Learning on the job vs learning institutionally: Presumably there is a changing relationship between these two learning arrangements as the workforce, including craft level, becomes more educated. In the newer knowledge-based industries, the trend towards institutional learning will be most marked. But even in the older industries like foundries where workers' formal education was minimal if it existed at all, it would be interesting to examine the impact of secondary education upon greater concern with quality, etc.

Analysis of the unqualified technician or 'Mistry': An important aspect of learning on the job relates to the hundreds of thousands of 'mistries' (senior mechanic or master) who in countless workshops across the country are responsible for welding, painting, building, machining, automotive repair, etc. etc. Are they a case of the good being the enemy of the best? In the sense that their learning has been rote, trial and error learning, and that they have little or no theoretical knowledge, they have been characterised as highly individualistic, yet conservative. They extemporise, but do so in a setting of un-standardised machines and products. At some point they too seem to relate to the problem of quality to which we have kept returning: '... the technical outcome of this fantastic expertise is often uncertain. Poor quality of craftsmanship and low maintenance standard of service equipment - from bicycles, automobiles, electrical goods, to manually-operated mechanical systems of all kinds bear testimony to this... unfortunate state of affairs'.

4. Changing Ideologies towards Science and Technology

In general, the various centres and groups mentioned in this paper have regarded science and technology rather positively. Certainly science would have to be taught better to have an impact and technology be more oriented to rural problems, but the extension of scientific method was not itself under dispute. In parallel, however, with the growth of groups concerned with the extension of scientific temper to poor schools and backward

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4 Aquel Ahmad, 'Scientific and Technical Human Resources in India', National Council of Science and Technology Panel on Futurology, DST, April 1977.
classes, there has grown up a critique of the role of science and technology in Indian society.

Over against the calls for scientific temper, or for national science campaigns directed towards poverty, disease and ignorance, science studies groups have drawn attention to the need more dispassionately to disentangle the relationships between state power and the science establishment, between contract science research and uncommitted research in universities and between the extension of modern science and the existence of local knowledge systems. One dramatic presentation of some of the issues in dispute between scientific temper and scientific danger exponents is available in the contrast between two short tracts. They offer a valuable counterpoint to the more applied research topics we have been discussing:


These controversies about the role of science are not necessarily academic. The signatories to the Statement on Scientific Temper work in major science teaching and research institutions, including some of those mentioned in this paper, and are concerned to challenge the obscurantism of many areas of Indian life. There is a near missionary note in parts of the Statement ('Our Nation's survival and its future depends on upholding Scientific Temper. Superstition shall not pass and darken its portals') but the group are sufficiently scientific to want 'to combat the tendency to treat science and technology as a sort of magic'. Problems of caste, class and corruption do not crumble away in the face of science, but 'when the social structure and stratification prevent the application of rational and scientifically proven solutions, the role of Scientific Temper is to lay bare the anatomy of such social barriers'.

This laying bare is not intended as an empty aspiration, but has already become, as we have seen, the method followed by Kerala's KSSP in making villagers aware of the politics of pollution and other development problems. It was also part of Kishore Bharati's non-formal science education, and figured prominently in the series of 'awareness' films produced by the

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42 Dipunker Gupta, 'State, Science and Universities', op.cit.
43 'A Statement ...' op.cit.
44 Ibid., p. 9.
45 'When we visited this village last year, we were amazed to see how technical terms such as sulphur dioxide, carbon monoxide, percentages and solubility had become part of the common idiom', Sadgopal, op.cit.
Space Applications Centre. It would, however, be rash to suggest that science is yet being widely used to demystify systems of oppression.

Indeed, the Counter-Statement would want to argue that science and technology have themselves been so intimately linked with oppression that they constitute a rather ambivalent armoury to wield in favour of the oppressed. The critics of 'development science', notably the Centre for the Study of Developing Societies, have increasingly begun to carry the debate about science beyond the pages of the academic journals and weeklies, and into discussions with activist groups around the country. In particular through their involvement with Lokayan, the loose network of activist groups in different states, the Centre (CSDS), has been drawn into discussing ideologies of science with some of the very groups using science in social transformation. In this connection, it would perhaps be valuable to have CSDS examine in some detail the assumptions about science and technology of the myriad groups flying a science flag in their rural development and education endeavours.

Conclusion

What stands out in this brief paper on Science, Technology and Education in India is the particularity of the science research environment. India has acquired an enviable position in its application of science and technology since 1947, compared with many other countries. Products can be as rapidly put into production as anywhere in the world. The design may be originally derived from elsewhere but there is frequently considerable originality in reproducing it in India. Some corners are cut, some quality is let slip, some packaging and presentation cheapened. But a local version of virtually everything is available in India.

The comments made here are not intended to question this achievement of self-reliance, but rather to reflect some current concerns about the science training and science utilisation policies that are related to these achievements in agriculture and industry. The ferment about scientific research, the education of scientific manpower, and the role of science in rural transformation are all high on the agenda of the research community. It seems that the lessons and experiences of the 1970s are beginning to come into sharper focus, and plans are being laid in many centres, institutions and agencies for the more targeted application of science, technology and education to rural and industrial development.

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