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India
Scientific and Technical Manpower Development in India

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ABBREVIATIONS AND ACRONYMS

AICTE	-	All India Council for Technical Education
CABE	-	Central Advisory Board for Education
GOI	-	Government of India
GDP	-	Gross Domestic Products
IAMR	-	Institute of Applied Manpower Research
IIT	-	Indian Institute of Technology
NTMIS	-	National Technical Manpower Information System
OECD	-	Organization for Economic Co-operation and Development
R&D	-	Research and Development
Rs.	-	Indian Rupees
SASED	-	South Asia Education Sector Unit, World Bank
S&T	-	Scientific and Technical
UGC	-	University Grants Commission

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PREFACE

This report presents findings and recommendations of a study conducted by a World Bank team* in association with Government of India officials, senior professionals and industry experts to: (a) understand critical issues in scientific and technical manpower development in India, and (b) identify strategies to reform the system – both at the systemic level and the institutional level. The study marks the culmination of a highly successful decade of cooperation between the Government and the Bank to modernize technician education in India, as also the beginning of a new phase of cooperation for major reforms in higher scientific and technical education.

The study began in April 1998 with a 'National Seminar on Scientific and Technical Manpower Development in India – Status, Need and Future Strategies', co-sponsored by the World Bank and the Government of India, with invited presentations from Government Departments, academic institutions, professional bodies, industry and international organizations. The seminar was followed by contracted studies on the current status, management, and financing of S&T education, and a labor market survey. At a workshop held in the Bank in January 1999, the results of the studies, a large number of policy and planning documents of Government of India, the recommendations made at international conferences on higher education, and many recent publications were examined and major issues were identified and strategies for reforms suggested. Based on these inputs a draft report was prepared and discussed at a workshop of stakeholders held in November 1999. The document was formally shared with Government of India in June 2000 for comments. This report takes into account all these inputs.

The Bank team thanks Prof. Ashoka Chandra, Special Secretary, Prof. D.P. Agrawal, former Joint Educational Advisor (Technical), Department of Secondary Education and Higher Education, Government of India and their colleagues for full cooperation in conducting this study and for facilitating the organization of the National Seminar and the stakeholder workshop. Thanks are also due to the Indian Institute of Technology, Delhi, the Technical Teachers Training Institute, Bhopal, the Institute of Hotel Management, Pune, the Directorate of Technical Education, Maharashtra and the National Project Implementation Unit, New Delhi for hosting the seminar and workshop and publishing the seminar proceedings. The team is grateful to all the invited participants for their valuable contribution.

The team is grateful to Prof. Ralph W. Harbison, former Sector Director, SASED, for guiding the team in the preparation of the report and for personally participating in the seminar and a workshop held as a part of the study. The team thanks the peer reviewers and many colleagues for their valuable contributions.

The team wishes to dedicate this report to the memory of Prof. Thomas O. Eisemon, who initiated this study with great passion but passed away in May 1998.

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* A list of the Bank team members is attached. A list of invited speakers and participants of the Seminar is also appended.

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EXECUTIVE SUMMARY

Background

At the start of the twenty-first century, India still has to meet the basic needs and aspirations of its one billion people. Despite being one of the largest economies of the world, over one third of its population is facing poverty. It has been recognized that only by competing successfully in the globally interdependent world economy can living standards be raised. For such competitiveness, every sector of economy in India requires major restructuring to enhance effectiveness and efficiency through intensive and judicious use of science and technology. This will trigger increased productivity, which should lead to expanded opportunities for employment, and thus a better quality of life.

India has formally recognized the importance of higher education and science and technology for national development and committed itself to the development of scientific and technical (S&T) manpower. Over the past fifty years the country has provided full policy support and substantial public funds to create one of the world's largest systems of higher education. However, the institutions/universities have mostly not been able to maintain high standards of education or to keep pace with developments in knowledge and technology. They are constrained by the explosion in enrollments, the limited financial support from the government, and most importantly, by an overall structure built on a myriad of controls and the supply-driven thinking of the past. The programs offered are unduly rigid (with fixed duration and course structure). Graduates from many middle and lower level institutions cannot find suitable employment due to limited job opportunities in the areas for which they are trained and because of a growing mismatch between their knowledge and current practice in the fields for which they are trained. The higher S&T education system needs urgent reforms and speedy changes. The system needs to be student-centric and not system-centric as at present.

The overall objectives of this study, conducted in association with Government of India officials, senior professionals and industry experts, are (a) to understand critical issues in S&T manpower development, and (b) to identify strategies to reform the system – both at the systemic level and the institutional level.

Major Issues

While India has one the world's largest stock of scientists, engineers and technicians, it has not derived full economic benefit from this skill base because of the mismatch/ inadequacy of education and training and the limited employment capacity of the labor market. The main problems facing the higher S&T education system today are:

- *Over-centralization and lack of autonomy and accountability:* The higher education system in India is subjected to multiple controls and regulations exercised by the central and state governments, statutory bodies (University Grants Commission/All India Council for Technical Education), university administration, and local management. Most institutions have little authority even in the areas of faculty appointments, student admissions, structure and contents of programs, evaluation methodology and financial management.

- *Resource constraint and wastage:* Post-secondary education is heavily subsidized despite severe constraints on flow of funds; government funding accounts for more than 90% of operating costs in most public institutions. The efficiency of resource utilization is poor due to internal rigidities even in the best-run institutions. The existing controls and regulations, in most cases, do not provide positive incentives to public institutions to mobilize other financial resources. There is very limited cooperation and sharing of physical and human resources among institutions and even less with industry or public research and development (R&D) laboratories. There is also large wastage of the limited resources available to the institutions in many forms, e.g., high dropout and failure rates, under-utilization of existing capacity.
- *Poor quality and relevance:* While some Indian post-secondary scientific and technical institutions offer world-class education and training in engineering and technology incorporating the "best practices", most institutions offer outdated programs with inflexible structures and content. There is a mismatch between student demand/labor market needs and institutional output and training modalities. Student demand, reflecting perceived employment opportunities and lower private costs, greatly exceeds the supply of places. A shortage of skilled manpower in fields critical for enhancing economic competitiveness is co-existing with chronic oversupply and unemployment of graduates in conventional fields, in which course contents have not been changed to meet the market needs. In addition, the Indian higher education system is not yet prepared to meet the new challenges posed by the increasing liberalization of the Indian economy, its gradual integration with the world economy, the very high international mobility of the workforce, and the rapid transformation of the society into a knowledge-based society.
- *Difficulties in retention of S&T personnel in education:* Institutions offering professional courses are unable to attract and retain qualified and trained faculty due to non-competitive pay packages, lengthy recruitment procedures, and the unattractive working environment. A large percentage of high ranking students from the better institutions who could fill such positions prefer to work and settle abroad or to take up a career in management.
- *Poor technology/infrastructure support:* In many institutions, physical facilities are largely outmoded and there is next to no maintenance. Probably no more than 20% of the institutions have the barest minimum of laboratory facilities and no more than a hundred institutions have any research activity worthy of note. The electrical power supply and the availability of clean water have become very unreliable in many parts of the country. The communication lines to most institutions are also extremely limited and of poor quality for computer or library linkages. Libraries do not stock current literature.
- *Limited access and regional disparity (equity):* The total enrollment in higher S&T education accounts for less than 2% of the age-cohort. Due to various socio-economic factors, some sections of the society (rural women, scheduled cast/tribes, and the physically disabled) are poorly represented amongst the beneficiaries. The potential of S&T education system is also not being exploited

fully to reach out and help people engaged in non-formal sector of economy (which accounts for 49% of the GDP). In addition, there are large regional imbalances in the availability of educational facilities, especially for professional courses.

A Strategy for Reforms

The above mentioned critical issues need to be addressed urgently if the Indian S&T education system is to meet the aspirations of millions of young Indians for a better quality of life, with greater economic opportunities. The system needs large-scale restructuring with significant reforms in (i) management, (ii) quality control and monitoring, and (iii) resource utilization and mobilization. It will require dedicated efforts to increase efficiency, to make the system more accessible and attractive to talented students and teachers, and to respond to industry and the society.

The strategy to implement reforms in S&T education needs to include:

- *Empowerment and accountability of individual institutions (and faculty)* through decentralization of authority, encouragement of innovations, and establishment of an entrepreneurial, responsive, participatory and accountable management culture.
- *Optimal utilization of resources* to minimize wastage and to attenuate further fragmentation of resources and *encouragement of larger private investments* in S&T education.
- *Mobilization of additional financial resources* through contributions/payments by students, parents, employers, alumni, government, business and industry, and through the generation of resources from consulting services, continuing education programs, the limited commercial use of institutional facilities, contract research, and the exploitation of intellectual property rights (IPRs).
- *Establishing effective quality assurance mechanisms* for teaching, recruitment of teachers, curriculum reforms, and student evaluation, with mandatory, but not centralized, transparent monitoring of the quality of physical and academic facilities and of the teaching/learning processes, taking corrective actions where necessary.
- *Networking to enhance capacity, improve quality and produce excellence:* networking of institutions/centers of excellence with other education and training institutions, government R&D laboratories, and industrial establishments.
- *Increasing access to S&T education* for the deserving through large-scale expansion in continuing education, community out reach programs, distance education and virtual university facilities and through a *reduction in regional imbalances* in S&T education capacity and quality.

Towards Implementing the Strategy

Implementation of the strategy for reforms will involve changes in processes and/or new actions at both the systemic and the institutional levels. It may be noted that many of these changes will not require any new investments. The aim is to make the existing system perform better by being more self-reliant than at present. Of course, some critical public investments will continue to be needed in areas where no facilities exist at present.

Systemic Processes: Some priority actions that need to be implemented include:

(a) *Governance*: All tertiary education institutions should be empowered in their operation and conduct of programs by being given academic, administrative and financial autonomy.
(b) *Accountability*: Allocation of public grants should be linked to institution performance in academic achievements, including the employment of graduates.
(c) *Funding*: Government should set up a S&T Education Fund both at the center and state level which could be accessed by educational institutions on a competitive basis. Government/UGC/AICTE should simplify their procedures of funding and provide incentives for the mobilization of resources.
(d) *Program relevance:* Institutes should be encouraged to undertake consulting services, continuing education programs, and sponsored R&D activities to make higher education responsive to the market needs.
(e) *Linkages:* Local, regional and national networks among institutions, government laboratories, industrial laboratories and other knowledge producers should be facilitated for an optimal utilization of available infrastructures and intellectual/knowledge resources of individual network institutions.
(f) *Equity:* Efforts should continue to reach out to the deserving students in remote areas, rural women, and the physically disabled through special programs including scholarships, distance education and guided self-learning.

Institutional Processes: The following actions are suggested at the level of institutions:

(a) *Self-governance:* All institutions should be given sufficient autonomy to establish an entrepreneurial, responsive, participatory and accountable management culture, adapting successful models.
(b) *Student selection and counseling:* Institutes should select students through a transparent process for assessing the merit and aptitude.
(c) *Faculty selection and development:* Heads of institutions and departments should be selected in a transparent manner on the basis of leadership qualities. Faculty should be selected based on proven academic merit, aptitude and ability for teaching, and peer reviews. There should be provision for induction training of teachers for training in curriculum design, lesson planning, laboratory exercise setting, and management of classroom and laboratories.
(d) *Curricula renewal:* All curricula should be reviewed and revised at regular intervals. There should be provision for introducing new topics in emerging fields with full consultation with local employers.
(e) *Program flexibility:* Academic programs should be designed to provide maximum flexibility to students to select courses according to their felt needs.
(f) *Student evaluation:* Teachers should be expected to develop parameters for judging the analytical, innovative and problem-solving abilities of students and to diminish the emphasis on memory and retention testing.
(g) *Self-assessment:* Each institution should publish annually its academic achievements including information on the employment of graduates.

SCIENTIFIC AND TECHNICAL MANPOWER DEVELOPMENT IN INDIA

………India's enormous resources of man-power can only become an asset in the modern world when trained and educated.

Scientific Policy Resolution, Government of India, 1958

I. INTRODUCTION

1. Background and Objectives of the Study

1.1 At the start of the twenty-first century, India still has to meet the basic needs and aspirations of its one billion people. Despite being one of the largest economies of the world, over one third of its population (equal to the total population of Latin America) is facing poverty, illiteracy and disease. Millions do not have access to adequate food, clean water, shelter, or employment. It has been recognized that only by competing successfully in the globally interdependent world economy can living standards be raised.

1.2 Every sector – be it agriculture, industrial production, energy, transportation, health services, communication, banking, commerce or administration – requires major restructuring to enhance effectiveness, efficiency and global competitiveness through intensive and judicious use of science and technology (S&T). This will trigger increased economic productivity, which should lead to expanded opportunities for employment, and thus a better quality of life.

1.3 India has formally recognized the importance of higher education and science and technology for national development and committed itself to the development of S&T manpower (Ref. 1, 2). Over the past fifty years the country has provided full policy support (Ref. 2-5) and substantial public funds to create one of the world's largest systems of higher education, a system which includes some internationally recognized institutions. The higher education system in large measure met the manpower needs in a bygone era of self-reliance. But it no longer does in the new environment in which high talent manpower must meet a single international standard.

1.4 As described in more details in Annex 1, India's higher S&T education system is mammoth if measured in absolute numbers of institutions and students, surprisingly small if compared with OECD and other key developing country competitors in terms of coverage of age eligibles or financial resources committed to it.

1.5 Over the last few years, the publicly funded institutions/universities providing S&T education in India have not been able to maintain high standards of education or to keep pace with developments in knowledge and technology. They are constrained by the explosion in enrollments, the limited financial support from the government, and most importantly, by an overall policy framework built on a myriad of controls and the supply-driven thinking of the past. The programs offered are unduly rigid (with fixed duration and course structures). Alongside the declining standards of public institutions, many private institutions also do not provide the necessary faculty, teaching materials, information access, or infrastructure needed for quality education in spite of fees, willingly paid, which are often very high. Graduates from many middle and lower level institutions cannot find suitable employment due to limited job opportunities in the areas for which they are trained and because of a growing mismatch between their knowledge and current practice in the fields for which they are trained. The higher S&T education system needs urgent reforms and speedy changes. It needs to be student-centric and not system-centric as at present. In the absence of such reforms, the system will decline further with much adverse impact on the whole economy.

1.6 The overall objectives of this study, conducted in association with Government of India officials, senior professionals and industry experts, are (a) to understand critical issues in S&T manpower development, and (b) to identify strategies to reform the system –both at the systemic level and the institutional level.

1.7 The study began in April 1998 with a 'National Seminar on Scientific and Technical Manpower Development in India – Status, Need and Future Strategies', co-sponsored by the World Bank and the Government of India, with invited presentations from Government Departments, academic institutions, professional bodies, industry and international organizations (Ref. 6). The seminar was followed by contracted studies on the current status, management, and financing of S&T education, and a labor market survey (Ref. 7-10). At a workshop held in the Bank in January 1999, the results of the studies, a large number of policy and planning documents of Government of India, the recommendations made at international conferences on higher education, and many recent publications were examined and major issues were identified and strategies for reforms suggested. Based on these inputs, a draft report was prepared and discussed in a workshop of stakeholders held in November 1999. The revised draft report was formally shared with the Government of India in June 2000 for comments. The present report is based on all these inputs.

B. An Overview of Major Issues

1.8 There has been a phenomenal growth in higher education in India. In 1950-51, only 263,000 students (in all disciplines) were enrolled in some 750 colleges affiliated to 30 universities. The total post-secondary enrollment in 1998 exceeded seven million students in university departments and some 9,700 degree colleges affiliated to 229 universities (or equivalent institutions), and over 9.5 million students in over 6,500 below-degree institutions (Ref. 11-13). Enrollment is currently growing at a rate of about 5.1% per year. Of the degree level students, only about 20% were enrolled for science and 5% for engineering courses. With increasing investments and the consequent large enrolments at the primary and secondary levels of education, the demand for higher education, especially professional courses, is growing rapidly.

1.9 While India has one the world's largest stock of scientists, engineers and technicians, it has not derived full economic benefit from this skill base because of the mismatch/ inadequacy of education and training and the limited employment capacity of the labor market. The main problems (elaborated in later sections) facing the higher S&T education system today are:

- The entire higher education system is *bureaucratized* with multiple controls and regulations exercised by the central and state governments, statutory bodies (University Grants Commission, All India Council for Technical Education, and others), university administration, and local management. Most institutions have little authority even in the areas of faculty appointments, student admissions, structure and contents of programs, and evaluation methodology.
- Post-secondary education is *heavily subsidized despite severe constraints on flow of funds*; government funding accounts for more than 90 percent of operating costs in most public institutions. The efficiency of fund utilization is poor due to internal rigidities even in the best-run institutions. The existing controls and regulations, in most cases, do not provide positive incentives to public institutions to mobilize other financial resources. There is *very limited cooperation and sharing* of physical and human resources among institutions and even less with industry or public R&D laboratories, because the earlier centralized systems have resulted in isolationist approach in almost all institutions, even in the best ones. There is also large *wastage of the limited resources* available to the institutions in many forms, e.g., high dropout and failure rates, under-utilization of existing capacity.
- While some Indian post-secondary scientific and technical institutions offer world-class education and training in engineering and technology incorporating the "best practices", many institutions offer *outdated programs with inflexible structures* and content. There is a *mismatch between student demand/labor market needs and institutional output and training modalities*. Student demand, reflecting perceived employment opportunities and lower private costs, greatly exceeds the supply of places. A shortage of skilled manpower in fields critical for enhancing economic competitiveness is co-existing with chronic oversupply and unemployment of graduates in conventional fields, in which course contents have not been changed to meet the market needs. In addition, the Indian higher education system is not yet prepared to meet the new challenges posed by the increasing *liberalization of the Indian economy*, its gradual integration with the world economy, the very high international mobility of the workforce, and the rapid transformation of the society into a knowledge-based society.
- Institutions offering professional courses are *unable to attract and retain qualified and trained faculty* due to non-competitive pay packages, lengthy recruitment procedures, and the unattractive working environment. A very large percentage of high-ranking students from the better institutions who could fill such positions prefer to work and settle abroad or to take up a career in management.
- In many institutions, *physical facilities are largely outmoded* and there is next to no maintenance. Probably no more than 20 percent of the institutions have the barest minimum of laboratory facilities and no more than a hundred institutions have any research activity worthy of note. The electrical power supply and the availability of clean water have become very unreliable in many parts of the country. The communication lines to most institutions are also extremely limited and of poor quality for computer or library linkages. Libraries do not stock current literature.

- *Limited access and regional disparity (equity):* The total enrollment in higher S&T education accounts for less than 2% of the age-cohort. Due to various socio-economic factors, some sections of the society (rural women, scheduled castes/tribes, and the physically disabled) are poorly represented amongst the beneficiaries. The potential of S&T education system is also not being exploited fully to reach out and help people engaged in non-formal sectors of economy (which accounts for 49% of the GDP). In addition, there are *large regional imbalances* in the availability of educational facilities, especially for professional courses.

C. A Strategic Approach to Improvements

1.10 The above-mentioned critical issues need to be addressed urgently if the Indian S&T education system is to meet the aspirations of millions of young Indians for a better quality of life, with greater economic opportunities. The system needs large-scale restructuring with significant reforms in (i) management, (ii) quality control and monitoring, and (iii) resource utilization and mobilization. It will require dedicated efforts to increase efficiency, to make the system more accessible and attractive to talented students and teachers, and to respond to industry and the society.

1.11 The strategy to implement reforms in S&T education needs to include:

- *Empowerment of individual institutions (and faculty)* through decentralization of authority, encouragement of innovations, and establishment of an entrepreneurial, responsive, participatory and accountable management culture.
- *Optimal utilization of resources* to minimize wastage and to attenuate further fragmentation of resources and *encouragement of larger private investments* in S&T education.
- *Mobilization of additional financial resources* through contributions/payments by students, parents, employers, alumni, government, business and industry, and through the generation of resources from consulting services, continuing education programs, the limited commercial use of institutional facilities, contract research, and the exploitation of intellectual property rights (IPRs).
- *Establishing effective quality assurance mechanisms* for teaching, recruitment of teachers, curriculum reforms, and student evaluation, with mandatory, but not centralized, transparent monitoring of the quality of physical and academic facilities and of the teaching/learning processes, taking corrective actions where necessary.
- *Networking to enhance capacity, improve quality and produce excellence:* networking of institutions with other education and training institutions, government research and development (R&D) laboratories, and industrial establishments.
- *Increasing access to S&T education* for the deserving through large-scale expansion in continuing education, community out-reach programs, distance education and virtual university facilities; and through a *reduction in regional imbalances in S&T education capacity and quality.*

1.12 These six elements of a strategy when implemented could respond well to the issues and challenges noted earlier. The existing policy documents and action plans of the Government of India and its agencies dealing with higher/technical education already include these elements in some form or the other. Some of the elements have already been implemented on a limited scale. What is needed now are some well-planned and well-coordinated processes and schemes to implement the reforms on a large scale to make a visible and sustainable difference.

1.13 The suggested reforms, when implemented, could help achieve ***a vision for the higher scientific and technical education*** which can be stated as follows:

Building on the available infrastructure, large social demand and untapped potential, it is possible to transform the higher S&T education system in India, such that it will:

- Be comparable to the best in the world
- Provide equitable access on merit to the deserving from all groups
- Maximize innovative, intuitive and problem-solving skills
- Evaluate and reward originality, creativity, and initiative
- Sensitize students to economic, social and environmental issues
- Prepare students for life-long learning
- Make S&T teaching an attractive profession
- Have close linkages with industry, R&D organizations, and the service sectors

1.14 With this objective in view, the following sections elaborate further on the current status and policy framework, the major issues, a strategy for reforms and the essential processes needed for its implementation.

II. HIGHER SCIENTIFIC AND TECHNICAL EDUCATION SYSTEM IN INDIA

A. Current Status

2.1 India has a long history of education and teaching of pure and applied sciences dating back to over 2600 years. Its early contributions in mathematics, biology, medicine and astronomy are well recognized (Ref. 14). Unfortunately, much of its glory was lost during the medieval period. During the 19th century, a few western-type universities were established. Most of them were established through individual efforts, a few were based on community efforts. Some of these reached world class quality. Recognizing the value of science and technology (S&T) for economic development, major emphasis was laid again on higher education and S&T after India gained Independence in 1947. Today India possesses Asia's oldest, largest and most diverse infrastructure for S&T education and training, and this infrastructure has already made important contributions to the country's scientific and industrial development.

2.2 Soon after independence, the Government of India established milestone institutions in the country to provide leadership role in higher education in engineering and technology. These Indian Institutes of Technology (IITs), one in each region, have developed global reputations. In addition, India has a few front-ranking universities/ institutions for engineering and applied science education (e.g., Indian Institute of Science, Roorkee University, Anna University, Jadavpur University). Regional Engineering Colleges, Technical Teachers Training Institutes and some well-established state engineering colleges form the second tier of technical education, and these are followed by some 500 other engineering colleges and 1100 polytechnics, both public and private. This system is producing about 6,000 postgraduates, 65,000 graduates and 95,000 diploma holders in engineering every year (Ref. 8, 9).

2.3 Higher education in science in India is almost completely conducted by university departments and some 5000 government/aided colleges affiliated to the universities. Under-graduate teaching is largely handled by colleges. The system is producing an impressive number of science degree holders every year (estimated to be about 190000, 38000 and 3800 at B.Sc., M.Sc. and Ph.D. levels, respectively). However, there are also very high dropout and failure rates (over 40 percent) at the under-graduate level. Furthermore, due to limited job opportunities and growth prospects, a large percentage of the graduates do not pursue science as a career (Ref. 9, 13, 14).

2.4 Demand for admission for the first degree course in engineering in most states far outstrips the available capacity. The heavy demand for professional courses and lack of innovative response from government-funded institutions have led to: (i) the establishment of hundreds of private self-financing professional educational institutions; (ii) a massive increase in private training enterprises, mainly in computer applications and information technology, on a commercial basis; (iii) a large number of private tutorial institutions preparing students for entrance tests for professional courses and public examinations; (iv) campaigns by foreign universities to admit undergraduate students from India in large numbers on a full fee basis; and (v) some foreign universities offering distance education/regular courses in India through private promoters. While the involvement of the private sector in professional education is a welcome development and needs to be encouraged, the quality of the programs offered and the learning environment created in many private institutions (as also in many public institutions) is a source of major concern. The regulatory mechanisms (of the AICTE/UGC) for quality control need to be more effective in such cases.

2.5 India loses a significant percentage of its trained manpower every year to the developed countries. In 1998 nearly 34,000 Indian students and 30,000 professionals went to the US alone (Ref. 15). Past trends indicate that majority of students do not return after completing their studies abroad.

2.6 As discussed in greater details in Annex 1, S&T educational institutions in India are subject to multiple levels of governance and control, and a complex procedure of financing. The Government of India maintains central universities and institutes of national importance. The University Grants Commission (UGC) and the All India Council for Technical Education (AICTE), established by Acts of Parliament, have the statutory responsibility of promoting, regulating and maintaining standards in general higher education (including science) and technical education, respectively. Funds under the union budget approved by the Parliament are released through UGC/AICTE/ Department of Education. At the state level, universities come under the purview of state Departments of Education (or Higher Education, in some states), which are responsible for planning and maintaining all higher education institutions.

2.7 Generally, universities also follow very rigid rules in all administrative, academic and financial matters in governing their departments/faculties and affiliated colleges. Very large universities with numerous colleges face major problems of governance and maintaining standards. Most colleges have little control over admissions, appointment of faculty or other staff, program design, the academic timetable, curricula, evaluation methodology, examinations, or the procurement of goods and works. These are all decided and controlled by state directorates or the university administration. *The excessive sets of controls that are meant to maintain standards and accountability have in fact introduced major inertia in the system.* The net effect is that the system is now unable and even unwilling to respond to the needs of students, society and the labor market.

2.8 *Higher education, including science education is almost entirely dependent on government funding.* Technical education is still largely dependent on government support. India spends about 3.6% of its GDP on education against the desirable target of 6% (Ref.16). Of this expenditure, higher education and technical education have a share of about 16.4%. This translates into an average annual expenditure of about Rs. 11,800 (US$300) per student. There is a large variation (ranging between Rs. 5,000 to Rs. 100,000 per student per year) in actual expenditure depending on the courses of study and the institution.

2.9 Annex 1 presents a more complete discussion of the system, with data on its structure (its size, scope, courses offered, duration, regional variations, etc.), governance and financing of S&T education, the labor market for engineers and technicians, and the problems being faced at present.

B. Policy Support

2.10 The *Constitution of India* (Seventh Schedule) places the responsibility on the Government of India for co-ordination and the determination of standards in institutions for higher education or research, and in other scientific and technical institutions. The Government's responsibility also covers central universities and institutions for S&T education that are financed by Government of India wholly or in part and declared by the Indian Parliament by law to be institutions of national importance. The Constitutional Amendment of 1976 (Ref .1) places education, including technical education, in the concurrent list (which implies joint responsibility) of the Government of India and the states.

2.11 Over the years the Parliament has adopted major policy resolutions related to higher education and S&T. Developments in the S&T sector in India have largely been guided by its *Scientific Policy Resolution (1958)* (Ref. 2), which lays emphasis on: the cultivation of science, scientific research, the training of scientific and technical personnel to fulfil the country's needs, and encouragement of creative talent and individual initiative for the acquisition and dissemination of knowledge in an atmosphere of academic freedom.

2.12 The *Technology Policy Statement* (Ref. 5) states that Research and Development, together with S&T education and training of a high order, will be accorded pride of place. Basic research and the building of centers of excellence will be encouraged. The quality and efficiency of the technology generation and delivery systems will be continuously monitored and upgraded. The policy statement calls for strengthening of the linkages between educational institutions, R&D establishments, industry and governmental machinery.

2.13 The *National Policy of Education* (adopted in 1986 and modified in 1992- Ref. 4), which improved upon the National Education Policy of 1968 (Ref.3), has detailed sections on higher education and on technical education covering a range of operational, financial and technical issues. The Policy recognizes education to be a unique investment in the present and the future. In higher and technical education it lays emphasis on equal access on requisite merit, student mobility between institutions, networking of institutions with each other and with R&D organizations, greater institutional autonomy with accountability, research, quality and responsiveness of the curricula, resource mobilization, and institutional excellence.

2.14 The policy statements act as guiding principles in developing plans and programs for government support for S&T manpower development in India. The *IX Five Year Plan* (1997-2002) of the Government of India identifies the following critical areas for action in Higher Education (Ref. 17):

(i) Relevance and quality
(ii) Use of media and education technology
(iii) Structure of curricula and flexibility
(iv) Access and equity
(v) Management of education
(vi) Resource mobilization and utilization

2.15 On S&T manpower development, the IX Five Year Plan document states:

- Scientists with exceptional capabilities should be nurtured and supported fully by offering them, within India, facilities comparable with international standards.
- There is need to create conducive environment in educational institutions for developing creative skills and innovative capabilities.
- The academic community should gradually motivate the faculty to do research by giving them a sense of empowerment and autonomy of functioning within the university system.
- There is need for introduction of some high quality undergraduate science programs at selected institutions.

2.16 The long-term vision for India in various sectors is also developed by expert groups and professional bodies from time to time to help the central and state governments, management bodies of institutions, and industries to plan their activities and to take advance action. The 25-volume *"Technology Vision for India 2020"* (Ref. 18) prepared during 1994-95 by National Committees, and published by the Technology Information, Forecasting, and Assessment Council (TIFAC), covers sixteen key sectors such as agriculture, agro-food processing, chemical industries, life sciences, engineering industries, electronics, and strategic industries. The document makes specific recommendations for action with the vision that India should become a developed nation by 2020 and one of the five biggest economic powers. The S&T institutions can play a major role in realizing this vision.

2.17 India is a signatory to several international policy declarations related to education and S&T. One such declaration is the *World Declaration on Higher Education* of 1998 along with the *Framework for Priority Action for Change and Development of Higher Education* (Ref. 19), which lays emphasis on: (i) quality and relevance, (ii) equity, (iii) better governance and financing, (iv) linkages and mobility, and (v) social responsibility of higher education.

2.18 It is clearly observed from the above (see **Annex 2** for more details) and numerous supporting documents that India has committed itself to policy support for S&T manpower development. There is also a process of systematic planning. These policies and plans have helped India to develop a vast infrastructure for higher S&T education. However, differing interpretations and implementation of the policies have also led to over-centralization of authority, bureaucratization of controlling agencies, and over-dependence on government support and interventions. The system has become too big to ensure quality and accountability with such centralized control. *There is a lack of state-level policy framework to support the national policies.* There is little community participation. Innovations and initiatives by institutions and their faculty are also lost in the process.

C. Sectoral Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

2.19 A detailed analysis of the S&T education system's strengths and weaknesses, and the resulting opportunities and threats are beyond the scope of the present study due to the enormous size and coverage of the system and the limitations of available data. Even a sample analysis covering the whole country is not easy. What is attempted here, instead, is to list some common observations in critical areas, applicable to a majority of institutions, based on the available literature and views expressed by experts knowledgeable about the system. Table 1 presents important observations on strengths, weaknesses, opportunities and threats in some critical elements (policy and planning, finance, administration, infrastructure, faculty, students, curricula, and evaluation system) of the higher S&T education system in India.

2.20 The main *strengths* of the S&T education system are that it is well structured, it covers nearly all disciplines and offers programs at a very low cost to the students. It has largely met the skilled manpower requirement of the economy in the past and has the potential to meet the future needs too. It is generally self-reliant and has received international recognition for the quality of some of its output. The system has had extensive support from the Government and provides open access to the meritorious with little discrimination and full freedom of thought and action. The faculty is generally well qualified, and the approved teacher:student ratio is fairly high.

2.21 The apparent *weaknesses* of the system include lack of quality assurance, obsolescence in curricula and teaching methodology, poor infrastructure and technology support, political interference, lack of autonomy in decision making (both academic and administrative), absence of a global perspective, a failure to attract and retain the talented to the teaching profession, disinterested students, and an overall shortage of financial resources. Both external and internal efficiencies of the system are poor leading to enormous wastage. There are no incentives to utilize the system to its full potential and mobilize additional resources. Institutions are isolated with little interaction with employers, community, other academic and R&D institutions, and even within themselves.

2.22 There are enormous *opportunities* for building a vibrant high quality higher education system in S&T in view of the nation's determination to reach a developed and technologically self-reliant status by 2010 with a global advantage in information technology. National economy is growing at 6-7% per year. There is high competition for higher education and training. In addition, globalization of the economy and easy access to knowledge are redefining the role of the system, and opening it up for attracting students from abroad in significant numbers to gain economic advantage as well as political goodwill.

2.23 Growing mismatch with employment market, and failure to increase access of the deserving to a high-quality tertiary education system in S&T would pose major *threats* to securing the India's goal of self-reliance and progress. Failure to meet the aspirations of students could contribute to major unemployment, serious unrest, and ongoing exodus of talented people from the country. Poor quality products of the S&T education could hurt the competitiveness of industry and services with very negative consequences for the national economy.

2.24 The other main conclusions of the SWOT analysis are:

- Location adaptations are necessary but need a broader effective regulatory and support framework.
- Quality models exist but are not replicated widely.
- Excessive control of institutions is making the system drift away both from innovation and labor market needs.
- A main threat is the system's isolation/inward looking tendency.

2.25 The discussion of the current status and the simplified SWOT analysis suggest an urgent need for major reforms in the system to meet the current and future needs of India for high quality S&T manpower. The major issues needing attention in the design of a reform strategy are discussed in the next section.

Table 1: Technical and Scientific Manpower Development in India: Strengths, Weaknesses, Opportunities & Threats (SWOT) Analysis

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
POLICY & PLANNING	• Institutional mechanisms (CABE, UGC, AICTE, Planning Commission) exit for formulating policies and plans, and for ensuring quality • National Policy for Education adopted in 1986 and modified in 1992 • Science Policy, Technology Policy, Industry Policy, Information Technology Policy available for guidance • Periodic reviews of education at the national and state level	• Expansion rarely related to labor market demand, more on political pressure or regional aspirations. • Implementation of policy very tardy • UGC and AICTE's powers for control and regulation not effective. • Quality control mechanism inadequate and ineffective • Political/bureaucratic pressures in policy formulation, implementation and planning • Limited role of private sector, professional societies, national academics in policy formulation and implementation.	• Linking higher education with national development • Exploiting knowledge base and strengths for increasing India's share in the international market place	• Other countries attracting Indian students to their higher education system. • Non-availability of high level expertise in emerging areas will affect development
FINANCE	• Cost of higher education relatively lower than in other countries. • Government support liberal; majority of institutions publicly funded.	• Public financing becoming difficult leading to non-viable support to higher education • Private investment limited to professional courses • No incentives to institutions for financial prudence and increase in efficiency • Excessive controls leading to costly delays • Very low cost-recovery from students and beneficiaries	• Attracting full fee paying foreign students • Increasing cost-recovery substantially • Reduction of wastage	• Inadequate resources affect quality of education with consequential effects on national development and international competitiveness
ADMINISTRA-TION	• Fairly well-structured administrative system with reasonably democratic governance.	• Number of employees much larger than needed due to obsolete procedures and lack of mechanization. • Decentralization of powers ineffective. • Political and bureaucratic interference in decision making in appointments, transfers, admissions, etc. • Absence of incentive or reward system for good work • Lack of control on wasteful expenditure	• Improving cost-effectiveness efficiency and quality • Improving information flow • Networking of institutions and national labs. for quality and capacity enhancement • Optimal utilization of resources	• Frustration amongst teachers, students and staff due to lack of fair and transparent decision making could disrupt academic activities, lowering of the image of the institution
INFRASTRUC-TURE	• UGC and AICTE lay down norms for minimum necessary infrastructure for all institutions. Funds provided to upgrade facilities at reasonable intervals for public institutions. • Most public institutions provide some facilities for corporate living for staff, students and employees	• No depreciation system for generating funds for removal of obsolescence; government grants not sufficient for both periodic modernization of facilities • Maintenance of all facilities generally very poor • Very little sharing of expensive facilities at any level • Campus services usually not contracted out for fear of raising the cost of the service to the beneficiaries and often for keeping a large number of people employed	• Improving utilization factor for all infrastructure, using appropriate schedule, and preventive maintenance through contracted services, • Developing concept of virtual laboratories through simulation in place of	• Poor quality and low relevance of education due to obsolescence of workshops, laboratories, library, and learning environment • Large wastage due to poor utilization of available facilities

		• Technological inputs to classrooms, laboratories, conference halls, etc. very primitive	expensive laboratory equipment.	
FACULTY	• Faculty in some institutions of international quality. • Approved faculty/student ratio fairly high in the S&T education sector. • Faculty in a few selected institutions has access to latest developments and research facilities.	• Shortage of teachers in most professional institutions. • Low compensation package making teaching profession unattractive compared to other sectors • Faculty development strategy very sketchy • Career progress slow for most teachers leading to dissatisfaction and unrest • Many teachers have no research background, field experience or exposure to modern Educational Technology tools • Teaching load and other responsibilities very high giving little time for personal research, study or interaction with students • Inbreeding of faculty leading to absence of new ideas and cross fertilization	• Faculty molding students' career and values and developing attitudes for life-long learning through personal example, • Creating professional teams amongst networked institutions • Utilizing the services of working professionals • Training of selected senior students as teaching assistants	• Talented may not join teaching profession • Quality of education will decline rapidly with the quality of teachers - poor teachers produce poor graduates who may become teachers because they can get no other job and produce even poorer graduates
STUDENTS	• Students entering S&T sector are of fairly high scholastic ability. • International recognition of S&T graduates of selected institutions through graduate school admission, and employment in internationally competitive positions • Graduates of the system largely met the needs of the economy, • All students enjoy intellectual and personal freedom of thought, belief and action and suffer no discrimination due to race, color, caste or gender	• Most students accustomed to rote learning for doing well in examinations and in securing a job, and lack confidence in their abilities • Students lack opportunity for developing creativity • Part-time employment of students non-existent leading to over-dependence on parental support. • Absence of career counseling coupled with serious mismatch between education programs and labor market demands resulting in large scale unemployment of qualified manpower	• Reorienting large number of students to nation building • Liberalization of economy and its gradual integration with world economy have opened up the labor market for qualified and enterprising graduates to work anywhere in the world • Attracting international students in large numbers to Indian institutions because of low cost	• Over-emphasis on examination inhibits quest for knowledge and skills • Educated unemployed can create social tensions • Talented students may not be attracted to S&T • Talented students with resources or external support may prefer to study and settle abroad
CURRICULA	• Varied curricula available covering nearly all required courses at graduate undergraduate and diploma levels • Syllabi of courses in good institutions fairly modern and comparable to the best in the world. • Medium of instruction in professional and applied science	• Inflexible and rigid curricula in most institutions • Common curricula used to meet varying output characteristics of graduates with no considerations for personal preferences and local work opportunities • Course syllabi highly detailed which help external evaluation process but inhibit innovative contributions from the teacher based on his experience. • Revision, modification and updating of curricula and	• Integrating knowledge and skill demands of the market with curricula and course contents • Identifying and developing hidden talents of students through a sustainable mixture of classroom teaching, self-	• Without frequent curricula revision meeting the emerging needs of the market place - both national and global, the output of the higher education system will not be able to make Indian industry internationally

	courses an international language, giving ready access to accumulated literature in S&T.	course detail a very lengthy exercise in most institutions leading to early obsolescence in curricula. • Expertise in curriculum design very limited, recourse is often taken to accept curricula of prestigious institutions at home or abroad without the flexibility, monitoring and control available in those institutions. • Curriculum implementation very poor, teaching mostly examination oriented, attention to students' difficulties in comprehension or application of knowledge not given due weight. • Emphasis on developing communication skills, problem solving abilities not present. • Not enough appreciation of new challenges in curricula even in engineering courses, environmental impact assessment, entrepreneurship, global perspectives, and international competitiveness.	learning, laboratory exercises, industrial attachments and real-life problem solving. • Developing competitive skills of professional students through design competition, communication skills through seminar presentation, investigative skills through summer research projects, and laboratory projects	competitive and Indian economy and polity vibrant
EVALUATION SYSTEM	• Secrecy in public examination operations is maintained across the system to ensure fair play. • Some good institutions use modern evaluation techniques and use them as feed back to correct deficiencies in the teaching/learning process.	• Except in some good institutions routine examination performance is the only parameter for evaluation of students' abilities and effectiveness of learning process. • Continuous evaluation of students not systematized in most institutions. • Examinations often memory-based and rarely test students' analytical and problem solving abilities. • Lack of transparency and openness leads to student dissatisfaction and unrest. • Laboratory training is rarely tested properly. • Examinations with ample choice in answering. questions often leads to students ignoring some parts of the syllabi and still qualifying satisfactorily. • Indian examination system is predominantly external with teachers who teach having little say in setting the question papers and evaluation of students' response. • Extensive private tutoring often kills learning motivation and initiative of students, and inhibits interaction between teachers and taught both in the classroom and outside the classroom.	• Developing continuous evaluation mechanisms and making them integral to the teaching-learning process • Giving greater responsibilities of evaluation to teachers who teach and interact directly with students to give credibility to the process by making it both fair and transparent.	• Arbitrariness in evaluation and lack of transparency can lead to student unrest, and lower image of the Indian higher education system.

III. MAJOR ISSUES

3.1 As noted already, the higher S&T manpower development system in India is facing a major crisis due to its rapid growth, limited resources, high wastage and over-centralized governance. It is unable to maintain quality and relevance and is thereby losing its capability to respond quickly and adequately to the country's needs. The system is also facing new challenges posed by the rapid globalization of the economy, the modernization of industry and the knowledge explosion. Some major but tractable issues faced by the system include:

- *A. Over-centralization and lack of autonomy and accountability*
- *B. Resource constraint and wastage*
- *C. Poor quality and relevance*
- *D. Difficulties in retention of S&T personnel in education*
- *E. Poor technology/infrastructure support*
- *F. Limited access and regional disparity (equity)*

These issues are discussed briefly in the following paragraphs.

A. Over-centralization and Lack of Autonomy and Accountability of Institutions

3.2 *The centralization of authority at various levels and multiple controls* (by government, regulating bodies like UGC/AICTE, funding agencies, university administration and local management) have engendered an enormous lethargy in the system of tertiary education in India. Centralization has resulted in increased bureaucracies at all levels, malpractice in examinations, outdated curricula, disinterested faculty, institutional administrators who do not know how to administer or lack the necessary authority, and frustration with the system amongst students. It has taken away flexibility from budgets and led to wasteful practices. Worst of all, it has all but destroyed initiative by faculty members in many institutions.

3.3 *The absence of autonomy in academic decision-making has inhibited innovations* in curriculum offerings and in teaching/learning methodologies and evaluation mechanisms. The system has therefore tended to prepare students mainly for examination success rather than developing the knowledge, personality and skills necessary for success in the labor market. Numerous university rules and government fiats govern the selection of students, the appointment of faculty and support staff, career promotion policies, and the maintenance of campus discipline. Government colleges do not have the power to receive grants from non-specified sources and to manage funds received, allocated, or generated from their own efforts.

3.4 Most universities (which are technically autonomous), and colleges which receive government funds come under the administrative control of state and central bureaucracies. Government's administrative control is often exercised without adequate information and without consultations with institute management. In many cases, government officials and political representatives interfere with the normal day-to-day functioning of the institutions in admissions, staff appointments and promotions, purchase of equipment, and the award of construction contracts. This *interference causes* *delays in decision making, lowers the quality of management, and affects academic values and responsibility.*

3.5 All institutions in India work under some legal framework – Central or State Acts and Statutes, Memorandum of Association, Societies Registration Act, etc. The objectives, functions, and operational methods, including procedures for disciplinary action, are often specified in these documents. Even a well-justified deviation from the written procedures to meet emergencies (of staffing, for example) often lead to legal complications and prolonged court cases limiting freedom of appropriate action. Procedures to amend or modify legal constraints are usually very time-consuming.

3.6 While procedural audit is carried out in minute details, *there is no systematic evaluation of institutional performance*. So there is little incentive to excel and plenty of scope to evade responsibility. With a few exceptions, there is no system of feedback from lower levels to higher ones, no feedback by students on the courses taught, no evaluation by teachers of the courses prescribed. There is also no opportunity for evaluation of administrators or administrative policies by any person affected by them.

3.7 The Indian society is becoming disenchanted with the poor quality of teaching, growing campus in-discipline, recurrence of campus agitation, and the closure of some academic institutions on one pretext or another. In many universities, it appears as if there is no institutional accountability for the teaching/learning process, the quality of education and research, and the maintenance of the academic calendar.

B. Resource Constraint and Wastage

3.8 India has a tradition of full public support to higher education, both at the central and state levels. Government subsidies still account for more than 90 percent of operating costs in most public institutions. Only in recent years has there been any significant private investment, but it is limited mainly to professional courses. Due to rapid expansion of the system and rising cost of education, public resources have been over-stretched. In addition, public subsidy is biased in favor of the elite universities/ institutions. *Public resources to support quality improvements in other scientific and technical institutions are fast diminishing.*

3.9 In most institutions, *salaries form the largest part of the operating cost*, ranging between 60-80%. After paying for non-salary operating expenditure (water, power, transport, furniture, etc.), many institutions spend as little as 6 percent on teaching material and student welfare (books, equipment, consumables, scholarships, etc.) against the desirable norm of 14-15% (Ref. 10).

3.10 *Low cost recovery in education at the tertiary level:* Fees charged to students at most public institutions represent no more than a small fraction of the real costs (less than 5 percent in most universities). Levels of cost-recovery for different levels or fields of study often have little or no relationship with either the cost of education, or the labor market or student demand. Students receive almost free education at universities irrespective of their paying capacity. Regulations do not provide any incentive to public institutions to mobilize resources; for example, in most cases, any revenue generated by government institutions goes, in large part, to the state/central government exchequer and not to the institution. A major part of any revenue earned by institutions gets adjusted against their approved allocation from the government.

3.11 *The preponderant share of the S&T funding pie goes to government laboratories* and research institutes that do not participate in education. An estimated 95 percent of the total budget for the S&T sector is for activities which do not, directly or indirectly, benefit the education system. Clearly, the non-educational part of the S&T sector holds the vast majority of the research facilities and expertise that are important to higher education. In the absence of effective mechanisms for linkages, there is no use of these facilities and expertise by the higher education sector.

3.12 *Over-exploitation of social demand:* While a few institutions in the private sector are utilizing the fee earnings and donations for providing high quality professional education, *a large number of private institutions are also being run on commercial basis making significant savings* (of up to 50 percent of the approved fees collected) by curtailing expenditure even on critical teaching and laboratory inputs (see Annex 1 for more details).

3.13 *Wastage: There is large wastage of the limited resources available to institutions in many forms*: (a) the dropout and failure rates are as high as 40 percent in some cases, adding significantly to the unit cost; (b) many science graduates do not pursue a career in science; thousands of engineering graduates and science post-graduates are also lost every year as they go abroad or shift to a career in management/administration; (c) there is an over-supply of graduates in traditional areas, resulting in large unemployment/ under-employment; (d) a large percentage of seats remain unfilled in post-graduate courses in engineering due to the lack of demand and the non-availability of candidates who qualify a national level test for admission into post graduate studies; (e) some universities are months behind their academic calendar and delays in examinations and announcements of results often prohibit bright students from entering post-graduate programs of other institutions in time; (f) the existing infrastructure in most institutions is highly under-utilized with, for example, some laboratories and workshops being occupied only for a few hours in a week; and (g) vast lands available to some public institutions remain undeveloped for years, adding to the cost of maintenance and security; such lands are often acquired for or given to the institutions, much below the market value, by governments at a high socio-economic cost; (h) some of the outdated support facilities are carried for years by the institutions without much utilization.

C. Poor Quality and Relevance

3.14 *Mismatch between Student Demand/Labor Market Needs and Institutional Output & Training Modalities:* There are two related issues. First, student demand, reflecting perceived employment opportunities, greatly exceeds the admission capacity in some programs. Competition for admission particularly to quality programs and good institutions is particularly intense. Only one out of a hundred applicants to the prestigious Indian Institutes of Technology gets admission. At the collegiate level, the ratio of admissions to applications in engineering at some well-established institutions is about 1:30, while fewer than one in ten students applying to better polytechnics get admission. For degree courses in good science colleges, the demand is typically 1:5. For some applied courses, the demand is as high as 1:10. Second, mechanisms of financing and governance linking market needs with training are weak, contributing to: (a) skill shortages in fields important for enhancing India's economic competitiveness like information technology, bio-technology, material science, and (b) chronic oversupply in conventional fields, including the pure sciences. Rigid curricula prevent students from constructing training packages of subjects that will exploit niches in the labor market.

3.15 *The high demand for admission for professional courses has resulted in creation of admission capacity in many areas far beyond the needs of the economy.* A labor market analysis conducted by the Institute of Applied Manpower Studies in 1998 (Ref. 9) as a part of the present study shows (Annex 1) that at the present rate of admissions, there will be a significant surplus of engineering graduates and diploma pass-outs in most disciplines and particularly mechanical engineering and electronics engineering by the year 2002. On the other hand, a few disciplines like computer engineering, metallurgy, mining engineering will face a shortage of qualified personnel. The study also shows that in Karnataka (with a very large number of private and public engineering colleges), over 20% engineering graduates in several disciplines had to wait for over three years to get a suitable employment. This situation reflects both ill planning of programs and poor quality of training in many colleges.

3.16 *Inappropriate modes of instruction and the absence in curricula and course syllabi of modern topics that reflect the current state of art and that anticipate future innovations.* The absence of lifelong learning opportunities for teachers, coupled with the isolation of many teachers from the international community as well as from recent advances in their fields, is partially responsible for the inertia in curricula and course syllabi. Another issue is that few teachers participate in the generation of new knowledge in their fields. Since they do not consider themselves as stakeholders and their effort to remain current is not rewarded by their institutions, there is little incentive to update curricula and course material regularly. Lack of close relations and collaboration with industry and other sectors that employ graduates also contributes to the inappropriate curricula.

3.17 *Inertia and bureaucratic obstacles to changing curricula and course syllabi:* Over-centralization and a lack of local autonomy also contribute to the curricular problems at the tertiary-level institutions in India. The approval process for any modifications of curricula or introduction of new subjects often takes up to three years in some universities/boards of technical education. In the meantime, knowledge progresses and additional changes become necessary even before the previous changes are put in place. Additionally, *the dearth of current S&T information, especially from abroad, makes rational changes to the educational system difficult* to incorporate in a short period. A third bottleneck is the *limited capacity of teachers at the tertiary level to absorb new knowledge;* many are in locations that are isolated from advances and their training has not prepared them to seek and process information and to think in ways that readily accept changes. New technologies like the Internet that could alleviate this problem to some extent are not made available as the state is short of funds.

3.18 *Inadequate levels of intellectual pursuits* (especially Research and Development): The deleterious effects of the widespread absence of research and development by teachers at tertiary institutions are felt at several levels and in several ways by the S&T educational sector. *The country loses a major low-cost resource of bright students and young teachers who could contribute to the R&D efforts. Teachers do not keep up with the latest developments in their subjects and curricula become outdated.* Students are not exposed to current knowledge or to how knowledge is generated and they are not trained to keep abreast of the rapid developments in their field. Finally students are not attracted to join the S&T sector or teaching profession to help create and disseminate knowledge.

3.19 *Limited opportunities for life-long learning:* Advances in science and technology are occurring at a bewildering pace, creating special problems in curriculum planning and delivery. The half-life of many technologies has come down to only a few years. In this context, it has become essential that both teachers and non-teaching professionals should develop an attitude for life-long learning, and have exposure to advances in their scientific or professional field through continuing education programs offered by institutions of higher learning and professional societies. At present opportunities for such programs are limited. Also, since *there is very limited mobility between institutions, R&D laboratories (private or public sector) or industry, the stagnation in experience and knowledge base becomes more acute.* Only teachers who have themselves cultivated an attitude for life-long learning can instill this among their students so as to make them fight technological obsolescence over their working life.

3.20 *Limited exposure to peers within the country and abroad*: The limitation of resources for tertiary level educators in the S&T sector has led to their isolation. In the cases where sub-communities of S&T researchers and educators have been able to meet on a regular basis, networks allowing sharing of information and correlated planning for future development have been established. Unfortunately, such cases are rare. Additionally, *the physical and intellectual isolation of researchers in the S&T sector has resulted in the wastage of resources due to the duplication of research, investigating derived projects, or worse, reinventing the wheel.* Even where true international excellence is present within India, it is not always recognized abroad due to a lack of interaction with the rest of the world community.

3.21 *Impact of Globalization of Economy:* Increasing liberalization of the Indian economy, its gradual integration with the world economy, very high international mobility of the workforce, and the rapid transformation of the society into a knowledge-based society have posed a new challenge to the Indian higher education system (Ref. 20). The employment of Indian graduates particularly in professional fields has suddenly widened from narrow state and national boundaries to an international market place. Most institutions in India have not geared-up to meet this new challenge.

3.22 *Very poor linkages between educational institutions and end users, poor linkages within an institution*: There is little operational interaction both within and between institutions. The only exceptions to this general observation are the inter-disciplinary centers and inter-university research centers established at selected institutions/locations by the UGC. The lack of coordination of planning for new programs, facilities, and student enrollments has led to inefficient utilization of the limited resources. Perhaps what is most serious is the effect of the lack of coordination on the ability of students to study highly specialized subjects. Expertise and over-capacity at one institution are not being exploited by students at another institution because of rigid wall between institutions. There is a dearth of slots available to students in some areas and a surplus in others; better planning and coordination are needed.

3.23 With the exception of IITs, Indian Institute of Science and some University Departments, *most institutions are isolated from the industry and other employment sectors,* an important source of information and resources and the major market for the "products" of the institutions. Those products are mostly graduates, but they can also be technologies. To date, there have been few technologies transferred and few inputs from industry that have been taken advantage of by academic institutions in India.

3.24 *Brain drain*: Every year, thousands of professionals and students from India go abroad for higher studies and work. A large percentage of the best-trained students from the S&T sector leave the country to work and settle abroad. In some critical emerging areas, this percentage is reported to be as high as 40-50 percent from the IITs. The loss to India is two-fold: *the public cost of students' education is not recovered in terms of their direct contribution to the economy; their contributions to the economies of more developed nations places India farther behind in relative terms.* There is also significant internal brain drain from the S&T sector, with many high-ranking students shifting to administrative or management jobs. The issue of brain drain has been a subject of extensive studies and is not treated as a part of the current study.

D. Difficulties in Retention of S&T Personnel in Education

3.25 *Universities and other tertiary education centers are having great difficulty attracting (and retaining) high quality S&T manpower for the education sector*. The reasons for this unsatisfactory state of affairs are many, including unsatisfactory compensation packages, low social prestige of teachers, unreliable and non-transparent policies for promotion/upward mobility, suffocating control by unimaginative bureaucracy, limited opportunities for attending seminars/workshops/conferences for peer interaction, and the near absence of incentives and encouragement for young faculty for research. In addition, the Government colleges suffer from very long and frustrating recruitment procedures through State public service commissions, rigid rules, court cases, strict adherence to reservation policies in all selections and promotions, and Government-controlled placement and transfers of teachers. These disincentives result in teaching becoming the last career option for most of the competent S&T personnel.

3.26 *Research and post-graduate education in engineering and technology is confined to a few institutions and universities.* Despite attractive scholarships, nearly 50 percent of over 19,000 seats approved in 191 institutions for post-graduate education in engineering colleges remain vacant and less than 7,000 students per year complete the courses. Annually less than 400 research scholars' candidates complete their Ph.D. in engineering and technology. The low enrolment in post-graduate and research programs in engineering is partly due to lack of interest but mainly due to the very limited number of candidates qualifying for admission to post graduate programs through GATE (Graduate Aptitude Test for Engineering) - a national level qualifying test. The consequent low output of postgraduates, the main source of supply of teachers, is a major cause of concern for the technical education system, which already suffers from about 10, 000 vacant positions as of 1999.

3.27 Institute leadership plays the most critical role in attracting and retaining young talented faculty. *Many institutions in India are suffering from lack of appropriate leadership.* Many of the schemes for up-gradation and improvement of educational effectiveness and quality cannot be implemented due to the lack of an adequate number of competent educators and educational managers. Unless talented people are attracted back to teaching, quality education will continue to be out of reach for majority of the population. *The damaging multiplier effects of the poor quality education at the higher levels of the education system that prepares future teachers for all levels of education as also key personnel for all other sectors should not be underestimated.*

E. Poor Technology and Infrastructure Support

3.28 *Inadequate and aging infrastructure:* In many institutions, physical facilities are outmoded and there is next to no maintenance. Probably *no more than 20 percent of institutions have the barest minimum of laboratory facilities* and no more than a hundred institutions have any research activity worthy of note. The cost of acquiring and maintaining the sophisticated equipment needed for almost all S&T educational endeavors at the tertiary level is staggering even for more developed nations with smaller student populations and better infrastructure supports. Added to the cost burden is the fact that India has to import a significant proportion of the sophisticated research equipment and spare parts. Also the high temperatures and humidity in many parts of India, and instabilities in the power grid reduce the useful life of equipment.

3.29 *Poor management of existing facilities*: In India, government colleges and institutions depend on the State Public Works Departments (PWDs) for construction and maintenance of their buildings. College principals have little authority or funds for even minor repairs or maintenance of buildings and equipment. As a result, *buildings are generally in very poor shape and a significant percentage of equipment remains non-functional*. The regulations and procedures governing replacement or removal of obsolete equipment are so complex that the institutions prefer not to take any action, leaving such equipment idle and occupying precious space.

3.30 *Unavailability of reliable source of power, water and communication facilities*: The Electrical power supply has become very unreliable in many parts of the country, and so is the availability of clean water. The communication lines to most institutions are also extremely limited and of poor quality for computer or library linkages or access to information in national and international databases. As a *result most institutions have no access to well developed libraries or to computer systems except in a few institutions*. These infrastructure constraints have to be taken into consideration in developing any implementation mechanism for quality improvement.

3.31 *Inadequate access to information and delivery systems for information:* Despite some recent improvements, the infrastructure within India for the electronic transmission of information is woefully inadequate. Whole universities are not connected to the

Internet. Adequate numbers of computers are lacking in many institutions. Institutions are unable to subscribe to important technical journals, to buy new books and reference guides, or to obtain electronic databases.

F. Limited Access and Regional Disparity (Equity)

3.32 In spite of very significant expansion of higher education in the country during the last five decades, *only 6% of the relevant age group of 18-23 years are enrolled for higher education (with less than 2% in S&T education) due to the limited capacity.* This is well below the norm of about 30-40% for developed countries and lower than the percentage for several developing countries. The limited enrollment capacity, particularly in professional courses, has made the admission process highly competitive. Thousands of private coaching institutions in major cities and larger towns are training students at a very high private cost, for tests for admission to better institutions. This coupled with a large reservation of seats for various categories and high fees in self-financing institutions is making *admission to professional education beyond reach of many meritorious students.*

3.33 *The disadvantaged groups that are most poorly represented in higher S&T education are rural women, scheduled castes/tribes (SC/ST) and the physically disabled.* Although, central and state governments have made special efforts (provision of scholarships, reservation of seats, hostel facilities, etc.) for increasing the representation of these sections of the population in post-secondary education, a lot still remains to be done to increase their access to scientific and technical education.

3.34 The potential of the existing S&T education system is not being exploited fully to reach out and help people engaged in non-formal sector of economy, which accounts for 49% of the national GDP.

3.35 In India, *there is a wide variation between states and regions in the development of educational infrastructures due to historical and socio-economic reasons.* The southern and western states are ahead of the eastern and northern states in terms of number of institutions, admission capacity, and the quality and range of courses/programs. In addition, due to their liberal policies, four states (Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu) have also permitted establishment of many private professional institutions which admit full fee paying students from all over the country. On the other hand, there are states having highly inadequate facilities for S&T education to meet the aspirations of their school pass-outs

3.36 *In summary*, the problems being faced by higher education in general, and S&T education in particular, are highlighted by six major issues. The issues are inter-linked and resolution of one problem may help mitigate some of the other problems too. On the other hand, some issues may need to be resolved together. The problems in totality are so widespread, urgent and serious that they call for a major strategy for reforms of the higher S&T education system taking into account all of the issues.

IV. STRATEGY FOR REFORMS

4.1 To overcome the major issues discussed in the previous section and to achieve the stated vision (Section I.C), the Indian Higher Education System; and the S&T education sector in particular, need a strategic approach for large scale restructuring with reforms in: (a) management, (b) quality control and monitoring, and (c) resource mobilization. Dedicated and concerted efforts are required to increase the internal and external efficiencies of the system, to make the system accessible to the deserving and the deprived, to attract talented students and teachers, and to respond to industry and society. There is adequate policy support at the national level for the needed changes. There is also evidence of success, but on a limited scale. What is needed is to *implement integrated reforms backed by policy support effectively on a large scale*. Only such an approach will revive the whole system and enable it to meet the present and future critical needs of the country. In the absence of such reforms, the system and the country will continue to be handicapped in the current global race for a better comprehensive social and economic development. It is indeed a struggle for economic survival.

4.2 This study believes that a strategy to reform the higher S&T education system in India needs to include the following elements:

A. Empowerment and accountability of academic institutions
B. Optimal utilization of resources
C. Mobilization of additional financial resources
D. Establishing effective quality assurance mechanisms
E. Networking to enhance capacity, improve quality and produce excellence
F. Increasing access and reducing regional imbalances

When implemented, the overall reforms strategy these inter-linked elements, listed in an order of priority, are expected to respond well to the issues and challenges noted earlier. Actions needed under each of the elements are discussed next.

A. Empowerment and Accountability of Academic Institutions

4.3 The first and most critical reform needed in the revival of the system is to *free the individual teaching institutions from the present regressive bureaucratic controls of many bodies and to make them fully accountable for their performance*. Decentralization of authority and granting freedom to experiment with new ideas and methodologies, both academic and managerial, are as important in upgrading the quality of graduates as the adequacy of infrastructure facilities or the competence of the faculty. For increasing autonomy of individual institutions and ensuring their effectiveness, the following actions are suggested:

- Enhance *empowerment (with full accountability)* of institutions to include but not be limited to the authority: (a) to select and dismiss faculty; (b) to grant promotions on the basis of merit, performance and achievements; (c) to select students on the basis of criteria that are clearly publicized; (d) to take all decisions on programs offered as per the local needs within a framework specified by the affiliating university/Directorate; (e) to conduct their own evaluation of students; and (e) to take all financial decisions within their allocated budget with well defined financial management norms. At present, only a few public institutions have this authority. For most colleges these powers are centralized at state directorates or the office of the affiliating universities.

- Establish at each institution an *advisory board* composed of alumni and a mixture of industrial, academic and civic leaders. The duties of the board will include (but not be limited to) guiding the development of the philosophy of the institution and collecting feedback from students and employers; providing advice to the head of the institution, staff and even students concerning matters of practical interest (e.g., trends in the job market and ways of generating funds) and of intellectual interest (e.g., codes of acceptable conduct and potential new areas of pursuit) to the well-being of the institution. The board should be proactive as well as reactive.
- Establish a system for ensuring *external and internal accountability.* Internal accountability requires commitment of the teachers, students and the management to ensure timely action for conflict resolution and maintenance of education standards. External accountability can be monitored through a strict accreditation process and regular performance audits. Community, employers and controlling authorities need to be involved in this process. This assessment should form the basis for adjustments to the programs. Only accredited programs should be eligible for public funds.
- Establish a *corporate management style* of functioning in all institutions with responsibility/authority delegated from the Head of the Institution to Heads of departments and from the Heads of departments to the faculty. Decision making should be decentralized with full accountability to ensure faster response to changing educational demands.
- Create information systems at national, regional and institutional levels to help governance, planning and monitoring of the system based on information (rather than based on resources as at present).

B. Optimal Utilization of Resources

4.4 Most institutions are suffering from both the shortage and the wastage of resources. To *attenuate further fragmentation of resources* in the sector and to their optimal utilization, the following actions are suggested:

- Establish no new research institution with public funds without ascertaining that existing university and government laboratories are incapable of conducting the additional work. It is generally more cost effective to strengthen *and build on good existing institutions* rather than to create new ones.
- Re-examine the need for and viability of all S&T institutions with the intent of reapportioning S&T resources and *increasing the involvement of government laboratories/research institutes in higher education.*

- Establish no new programs or institutions for which incremental funding is not available for at least an 8-10 year period; when demand does not justify duplication of efforts among neighboring institutions, it should be discouraged.
- *Review periodically the continuation of all academic programs*; re-appropriate resources from non-viable programs with low employment potential to programs in high demand.
- Establish reasonable, *financially tenable student/teacher/other staff ratios*, keeping in view the new knowledge-based tools for teaching/learning process and modern and simplified methods of management and maintenance.
- *Share available facilities and expertise* among educational institutions, R&D laboratories and industrial establishments.
- *Maximize the utilization of available space and equipment* by optimizing student intake, by adjusting the academic calendar and timetable, and by introducing R&D, continuing education programs and consultant services in all institutions.
- *Analyze all causes of large student dropout and failure rates* and take necessary measures to minimize these, as they are major causes of campus unrest and for wastage of resources and manpower.
- *Encourage larger private investments in S&T education* and allow limited public funding to self-financing institutions, on a competitive basis, for quality improvement of teachers, curricula, and research.
- Establish clear *criteria for assessing success or failure* of all competitive grant awards to both public and self-financing institutions.
- Establish a system of *compulsory periodic performance audit* of all institutions.
- Allow development of self-funded private institutions of good quality to *exert competitive pressure on existing public institutions* to perform better and more efficiently.

C. Mobilization of Additional Financial Resources

4.5 To increase the resource base of empowered institutions, central and state governments should allow institutions to do the following according to their local context:

- Set *student fees as a significant percentage of real costs*, allowing large public subsidies only to the deserving students from poor families.
- *Build up institutionally managed endowment funds* from institute earnings, donations and government grants.
- *Obtain private sector funding for development activities*, as increments over the public funding, in a manner that does not compromise the intellectual integrity of the institution or its individual members (e.g., naming of buildings, libraries, professorships and scholarships after large donors).
- *Provide incentives to institutes and faculty* for involvement in continuing education programs for industry, consulting services, and for securing private funded research projects.
- Admit and *train foreign students* on an internationally competitive basis;
- *Collaborate with well-established institutions abroad* in research, educational programs and conferences and solicit international funding for the same;

- Compete for international opportunities to *provide technical assistance to developing countries.*
- Allow operation of Indian educational institutions abroad.
- *Patent and market inventions and technologies* developed at the institution; profits from patents should be shared by the inventors, their institution and sponsors, if any.
- Allow on a commercial basis *use of campus facilities* for service providers like banks, communication suppliers, cafeteria, etc., which should primarily serve the campus.
- Provide *incentives and social rewards for donors.*
- *Organize alumni for the purpose of soliciting annual donations*; the potential for additional resources, especially from non-resident Indians and other Indian Diaspora, is enormous.

Recently, IITs and some higher professional institutions have been empowered by the Government of India to do some of the above. This has brought positive results, making them more self-reliant and competitive. Some institutions in Andhra Pradesh have also initiated such efforts. These models need to be replicated on a much larger scale.

D. Establishing Effective Quality Assurance Mechanisms

4.6 Improvement in the quality of S&T education in India at the large number of institutions is a major challenge. Efforts are required to improve the quality of faculty, the effectiveness of teaching and the evaluation process, the level and relevance of curricula, and the utilization of the available physical infrastructure. It is also necessary to enforce an effective accreditation system with mandatory, but not centralized, transparent monitoring of the quality of physical and academic facilities and of the teaching/learning processes, taking corrective actions where necessary. Some possible actions to improve quality are summarized in the following paragraphs.

4.7 *Increase quality and effectiveness of teaching:* To increase quality and effectiveness of teaching the following are suggested:

- *Reward teachers of demonstrated competence* with the opportunity to obtain further education leading to advanced degrees.
- Implement a system of *student evaluations* of faculty and peer reviews of course coverage to enhance accountability of teachers.
- Establish a *faculty of science education/technical education* (on a competitive basis) at a university or institute where a large fraction of the teachers are research-active to undertake research and develop new teaching methods (i) based on interactive lecturing, Socratic and Edisonian methods, transformation of information into knowledge, and conceptual learning and (ii) emphasizing multimedia and interactive electronic tools.
- Provide each college student with a *faculty advisor* for academic matters.
- Periodically *re-certify teachers*; require those who are found inadequate to take additional training in subject matter and teaching methodologies.

- Encourage the use of *adjunct professors* from industry/government sector to augment expertise where the institutional faculty is inadequate.
- Demand a minimum level of physical presence by teachers/professors on campus and in the departments.
- Encourage but specify the *time allowed for external activities*, such as consulting, with the intent of assuring that teachers maintain their focus on educational activities and student contact.
- Promote and *reward good teamwork.*
- Provide and promote *modern teaching aids* and materials.

4.8 *Recruit and retain new faculty:* In India, it is a major problem to attract and retain qualified teachers in the S&T sector. The following strategy is suggested to deal with this situation:

- Provide special *grant opportunities to new faculty* during the first five years for establishment of research programs: new teachers cannot compete with their seniors on the basis of accomplishment; yet, the first years of their academic careers are crucial to their establishing a lifelong pattern of intellectual pursuit.
- Provide *funds for participation in conferences*: becoming a part of the community of scholars is integral to a teacher being able to utilize his/her talents fully.
- Ensure *research autonomy* within the department/faculty: it is extremely important that individual researchers be able to exercise their own creativity within the constraints of their infrastructure.
- Provide *opportunities to teachers for remaining current* in the field or gaining new knowledge in emerging fields; these should include time-release and tuition reimbursements.
- Make *compensation packages for teachers competitive* with those offered by the private sector for scientists and engineers of equivalent backgrounds and accomplishments; this should apply to technicians involved in sophisticated work also; they should have a career path which parallels in some ways those of professors.
- *Simplify the faculty recruitment process* by permitting institutions to advertise and select candidates according to an approved process and publicized criteria.
- Review and *revise the reservation policy* in faculty positions in S&T education to ensure that no essential faculty positions lie vacant for want of qualified candidates.
- Develop a transparent and fair *career advancement policy* to reward the deserving.

4.9 *Introduce curriculum reforms:* In Science and Technology growth of knowledge is very rapid; new technologies are being developed, applied, utilized and then discarded. The half-life of current knowledge in many disciplines is reduced to only a few years. This calls for frequent reviews and updating of the existing curricula and course content to make them more relevant to the needs of the economy and for institutionalizing processes for effecting desired changes in the shortest possible time. To meet these challenges and to overcome some of the ills of the current status of curriculum design and implementation, the following actions are suggested:

- Curriculum development should be considered an important activity of teachers in higher education and should be given the same weight as teaching or research in the evaluation of teachers' performance.
- Selected institutions (preferably the nodal institutions in the network of institutions, if a network exists) should take the responsibility for training teachers (in the network) in curriculum design and implementation, lesson planning, setting challenging laboratory exercises, modern evaluation techniques, classroom and laboratory management, and the development of innovative and creative abilities and an attitude for life-long learning.
- The nodal institutions should also take the responsibility for mobilizing the teacher resources (of the constituents of the network) for reviews, updating and modifying existing syllabi of courses on a continuing basis and in developing appropriate learning materials for use of both teachers and students. *Employers as well as industrial associations should be fully involved* in the modification of existing curricula and in developing new curricula and syllabi.
- University *curricula should be fully reviewed and revised periodically.* The curriculum design process should permit bringing the latest knowledge in the field to the classroom quickly without procedural delays.
- *Accreditation agencies should set guidelines* on the important aspects of curriculum design, for example (for engineering courses): (i) the relative weightage to main and subsidiary subjects and humanities and the social sciences; (ii) the importance of laboratory and design courses; (iii) the use of computers in problem solving and virtual design; (iv) the use of modern communication tools in information gathering, processing and dissemination; (v) the rigor of 'project activity' and the expectations of synthesizing knowledge and exercising judgement with respect to the subject matter studied; (vi) the new demands of reliability, safety, productivity, quality consciousness, technology assessment and international competitiveness; (vii) the requirements of environmental impact studies and the problems of environmental degradation; and (viii) exposure to entrepreneurial skills in the field of study.

4.10 Since many Indian and foreign graduates of the Indian Higher Education system will be working increasingly in international teams serving both Indian and international customers demanding global standards, the education system must, in addition to imparting S&T knowledge and skills:

- provide them with a global perspective on educational, cultural, socio-political, economic and industrial issues;
- prepare them to appreciate and value diversity of cultures and provide them some experience of living/studying/working in foreign lands;
- provide special education in quality management, productivity, environmental impact assessment, international trade and commerce, and international management; and
- develop interpersonal skills of good communication and cross-cultural understanding.

At present *no program in S&T education addresses these needs arising due the globalization of Indian economy.* Students from most institutions have no exposure to meet such new demands.

4.11 *Introduce reforms in student performance evaluation mechanisms*: The purpose of evaluation should not be limited to holding examinations but should determine the effectiveness of the teaching/learning process along and grade the students' abilities. For this purpose:

- Evaluations should be multi-faceted and should include written examinations, assignments, quizzes, design exercises, minor and major projects, literature surveys and information processing, and tests of oral communication skills, evaluation of creative and innovative approaches, and (towards working in groups) attitudes.
- A system of *continuous evaluation* of students' progress and performance for every course should be incorporated in the curricula of all institutions.
- *Modern evaluation techniques* should be developed using open-book examinations, objective-type questions, self-assessment, challenging laboratory and design assignments and group work and the results of these should be used as feedback for improving the effectiveness of the teaching/learning process.
- All *evaluations should be both transparent and open* so that students and parents have full faith in them.
- Teachers should be trained to develop *parameters for judging the analytical, innovative and problem-solving abilities* of students and to diminish the emphasis on memory and retention testing as present in most examinations today.
- A *credit system* should be introduced in all courses in Science & Technology and preferably in the entire higher education system. Credit transfer should be permitted from one institution to another under stated rules and procedures.
- Evaluation should not only be on knowledge and comprehension but also on communication skills and group dynamics compatibility.
- There should be a *maximum duration specified* for completing a course program, for instance six years for a 4-year program. Barring some exceptional circumstances, students who fail repeatedly or take leaves of absence over protracted periods should be required to leave the course or pay 100 percent of the actual cost of education

4.12 *Improve infrastructure and equipment maintenance:* The quality of S&T education is dependent critically on the quality of the available infrastructure. The following are suggested to partially mitigate the present situation:

- implement the concept of depreciation at the institutional level for timely replacement of obsolete equipment;
- allow additional grant proposals for installation, operation and maintenance whenever a piece of major equipment is purchased ;
- make the positions of skilled technicians more attractive at colleges and universities; commensurately, the quality of their training and opportunities for continued education should be increased;

- permit divestment of usable surplus capital equipment preferably to other public tertiary institutions;
- *empower the institutions fully with adequate funds for all routine maintenance of equipment and for repairs, maintenance and minor works in buildings* and all campus facilities, including library, computer centers, laboratories, workshops, residences and toilets; and
- establish major equipment repair facilities at nodal institutions.

4.13 *Monitor demand/supply mismatch as well as performance of all institutions*: It would be strategically desirable to make the higher education system in India more responsive to demand. The demand includes needs of the labor market, societal requirements, and those arising from globalization of economy and education. The existing mechanisms of UGC, AICTE, Council of Scientific and Industrial Research (CSIR), Department of Science and Technology (DST), Association of Indian Universities (AIU), Institute of Applied Manpower Research (IAMR) and National Technical Manpower Information System (NTMIS) hardly fulfill these and therefore they need to be restructured, strengthened and coordinated to monitor the supply/demand mismatch as well as the academic and administrative performance of institutions. Other non-governmental bodies may be encouraged to place their findings in accessible electronic media.

4.14 One can not over-emphasize *the need for periodic discussion of employers for designing the academic programs.* For example, information elicited by the IAMR (as part of the present study- see Annex 1) from the employers suggests that Digital Electronics & Communication, Computer Networks, Electronic Commerce, Broad Band Integrated Digital Networks, and Concepts of Operating Systems Development are the new areas likely to be of great interest and concern in the future in the area of Information Technology. In the Bio-Technology area, Plant Vaccine, Transgenic Plant Cell Biology and Biological Engineering are the areas identified. Advanced Materials Science, Advanced Tool Engineering, Computer Integrated Manufacturing, Digital & Micro-Electronics, Mechatronics, Plant & Equipment Maintenance and Product Engineering are the emerging areas identified in the areas of Manufacturing and Processing.

4.15 *Increasing the Role of Professional Societies*: In India, there are three Academies of Science and one of Engineering. There are also a number of professional societies/institutions including some in highly specialized areas. Some of these are also members of international professional societies/associations/academies. These bodies are a valuable intellectual resource. However, most of them are functioning in isolation from each other and from the Government, with little impact on the education system. *There is a need for the Government of India to involve these professional bodies much more in the planning and policy formation for modernization of education in science and technology.*

4.16 Continuous interaction of the education sector with the professional societies would provide valuable inputs to the former in determining the relevance of courses in the context of the requirements of the profession and the anticipated growth of knowledge in various disciplines. This would also provide teachers a forum for academic discussion and debate with peers. *The professional societies could also provide valuable advice on syllabi and curricula, and in accrediting courses.* They could help in disseminating results of educational innovations and research. They could also organize continuing education programs through new educational modes, including distance education, for upgrading professional competence and for life-long learning. They should also identify outstanding contributions made by faculty and students and support travel for attending conferences.

E. Networking to Enhance Capacity, Improve Quality and Produce Excellence

4.17 As stated earlier, most technical educational institutions and many science colleges in India lack the necessary human and physical resources for high quality education. Most of them function in isolation and do not get access to the facilities of even their affiliating university. Their capacity and efficiency can be enhanced significantly through networking with other institutions, R&D laboratories, industry, and the services sector. For such networks, institutions with better resources, capacity and empowerment would need to act as lead institutions or nodal points. There are some successful networks existing but on a very limited scale. The following actions are suggested to achieve this objective:

- *Network institutions and faculties/departments/individual teachers of different institutions on a geographic/theme basis:* This proposed cooperative utilization of the sector assets will not require enormous increases in investments; it networks the relatively well-equipped libraries, laboratories, etc., of the government laboratories and research establishments with the nearby universities/institutions, colleges and polytechnics; it also presupposes that the well-trained scientists at the non-educational institutes will participate actively in tertiary education; the central hub for each network will be an academic institution.
- *Create centers of excellence*: These centers of excellence (created by recognition or upgrading of existing institutions) are aimed at achieving educational excellence in teaching, research, consultancy and other services. Such excellence should be capable both of updating itself in accordance with the best of the global experiences and trends and of being responsive to Indian social and economic needs. Many elements are involved in building excellence. These include: *quality of human resources; attitude and commitment of faculty, staff and students; a shared vision; team work with encouragement and rewards for team building; access to information sources; interaction with the best of the peer groups in India and abroad; an adequate physical infrastructure; well developed educational technology systems; and an enabling management and academic environment.* Performance of the centers of excellence should be reviewed periodically and the title retained on the basis of continued performance.
- *Establish formal agreements for regional educational ins*titutions that are incorporated into the network to use equipment, library resources, maintenance shops and other key infrastructure elements at the recognized centers of excellence (to be selected competitively); the selected centers of excellence will serve as hubs for the affiliated institutions; each center will receive funding to establish well equipped laboratories, libraries, computer laboratories (including

access to electronic data bases), sophisticated equipment maintenance centers, etc., that will serve constituents at affiliated institutions; the affiliates should also be selected competitively—inclusion should be a privilege, not a right.

- *Establish formal linkages between two or more academic institutions* for combining their comparative advantage; encourage joint research and academic programs; and allow transfer of credits earned within one institution to another at the discretion of the student's parent institution.
- *Allocate all incremental S&T educational resources competitively:* funds should be awarded on a competitive basis to networks, institutions, faculties, departments, teachers/researchers who demonstrate through a formal proposal (plan) how they will utilize additional funds effectively.

F. Increasing Access and Reducing Regional Imbalances

4.18 Access to higher S&T education for all capable aspirants is an important element of the vision for the Indian higher S&T education system. While the on-going efforts to expand the system to adequately cover all regions and educationally backward areas of the country should continue, direct access to tertiary S&T education may not be possible for all the aspirants due to the cost of infrastructure. This may leave out thousands of aspirants from benefiting from the system. The following actions are suggested to meet this challenge:

- *Establish new institutions on a highly selective basis*: The effort should be to utilize the existing infrastructure to its maximum capacity with cost effective additional inputs. Publicly funded new institutions may be established only if there is proven demand for such education and there are no existing institutions in a region which could be expanded or strengthened to meet the needs.
- *Improve the facilities for education at the secondary level*: While India has launched major efforts to improve access to primary education, it is also necessary to improve access of rural women and the disadvantaged groups to the secondary education to prepare them for tertiary education and training and for better employment opportunities.
- *Provide financial and academic assistance to rural/disadvantaged* but high potential students selected through an appropriate aptitude test based on widely publicized criteria.
- *Expand distance education facilities:* India has developed a fairly extensive Open University system. However, its extent and depth in the tertiary S&T education sector is limited. A few of the professional societies have an established system of distance education. These systems should be expanded rapidly, utilizing many new cost effective facilities like the Internet, video-conferencing, computer-aided learning, etc.
- *Encourage larger private investment* in S&T higher education, particularly to reduce regional imbalance.
- *Link teachers at remote locations* to a primary faculty member at a central institutional node via teleconferencing; use television supplemented by learning modules as a mode to present lectures in remote areas.

- *Develop low cost, low maintenance laboratory equipment* with syllabi so that students will be exposed to hands-on demonstrations of theoretical concepts and will learn the limitations of data credibility.
- *Develop effective learning materials in local languages* to help students in rural and remote areas having limited exposure to English.
- *Develop special tools and learning material for the handicapped.*
- Develop/ expand continuing education and community outreach programs with explicit output oriented focus – aimed primarily at informal sector of economy and rural needs.
- Allow students to make *professional choice decisions later in their education.* The current system is too restrictive; it does not make provision for students who are undecided after the tenth or twelfth year of study.

4.19 In **summary**, an effort is made here to address the major issues listed in Section IV through a strategic reform approach involving seven elements, each with a number of possible actions. These inter-linked elements are presented in their order of priority. The next section deals with some of the processes involved at the systemic level and at the institutional level to implement this strategy for reform.

V. TOWARDS IMPLEMENTING THE STRATEGY

5.1 To achieve the stated vision for the higher S&T education in India (Section I.C), a strategic approach to reforms is outlined in the previous section. Its implementation will involve changes in processes and/or new actions at both the systemic and the institutional levels. It may be noted that many of these changes will not require any new investments. The aim is to make the existing system perform better by being more self-reliant than at present. Of course, some critical public investments will continue to be needed in areas where no facilities exist at present.

A. Systemic Processes

5.2 The following are some priority actions that need to be implemented at the systemic level. These are further summarized in Table 2.

(a) *Governance*: All tertiary education institutions should be empowered in their operation and conduct of programs by being given academic, administrative and financial autonomy. Well-established institutions should be given full autonomy, while others should grow into full autonomy status through graded stages, depending on their level of academic, managerial and financial competence, as judged by performance audits against well designed criteria at every stage. The process should be accelerated through proactive steps.

(b) *Accountability*: A system of periodic assessment of all teaching/research programs should be established and reports made available to the head of institution and the institute Advisory Board so that the institution can undertake recommended changes. Allocation of *public grants should be linked to institute performance in academic achievements,* including the employment of graduates.

(c) *Funding*: Government should set up a S&T Education Fund both at the center and state level which could be accessed by educational institutions on a competitive basis. All socio-economic ministries of the Government, as major employers of manpower generated by the higher education system and as major beneficiaries of developments in S&T should set aside a certain percentage (say 2%) of their development budget as their contribution to S&T Education Fund. Private sector companies and individuals contributing to the fund should be given attractive tax benefits.

(d) Government/UGC/AICTE should simplify their procedures of funding and provide incentives for the mobilization of resources by institutions, including greater cost recovery from students, so that they can achieve *greater self-reliance*. Institutions should be encouraged to set-up endowment funds with contributions from industry, charitable trusts, alumni, earnings from the limited commercialization of facilities, the exploitation of patents, etc. Student fees for courses should be set as a significant percentage of real costs with provisions for scholarships/loans to deserving poor students.

(e) *Program relevance*: Institutes should be encouraged to undertake consulting services, continuing education programs, and sponsored R&D activities to make higher education responsive to the market needs. Professional bodies, employers and communities should play a significant role in all policy and planning processes, in the evaluation of institutions and programs, and in all distance education/continuing education programs.

(f) *Linkages*: Local, regional and national networks among institutions, government laboratories, industrial laboratories and other knowledge producers should be facilitated for an optimal utilization of available infrastructures and intellectual/knowledge resources of individual network institutions. Joint running of postgraduate programs by these institutions, joint research and consultancies, and joint membership of complex problem-solving teams should be encouraged. Institutions should be given access to Internet facilities and to national and international databases. Existing libraries should be supplemented with electronic connections to computer networks for ease of access from any part of the University/institution.

(g) *Equity:* Efforts should continue to reach out to the deserving students in remote areas, rural women, and the physically disabled through special programs including scholarships, distance education, continuing education and guided self-learning.

B. Institutional Processes

5.3 The following actions are suggested at the level of the individual institutions:

(a) *Self-governance:* All institutions should be given sufficient autonomy to establish an entrepreneurial, responsive, participatory and accountable management culture, adapting successful models. All institutions should make efforts to bring about attitudinal changes in students and faculty to create an atmosphere of dynamism and creativity in the institutions.

(b) *Student selection and counseling:* Institutes should select students through a transparent process designed and announced for assessing the merit and aptitude of students. Weaker students admitted on social equity considerations should have access to additional help and preparatory programs to make up for any deficiencies. All institutions should have counseling, training and placement services to assist students in decisions on their academic programs and for finding employment.

(c) *Faculty selection and development*: Heads of institutions and departments should be selected in a transparent manner on the basis of leadership qualities. Faculty should be selected based on proven academic merit, aptitude and ability for teaching, and peer reviews. There should be provision for induction training of teachers for training in curriculum design, lesson planning, laboratory exercise setting, and management of classroom and laboratories. All institutions should prepare faculty development programs and meet the expenditures of teachers for higher courses, continuing education courses, and participation in international seminars. All higher educational institutions should computerize their libraries and academic and administrative functions and develop a suitable support for management decisions. They should also be linked to a National Educational Management Information System to help in planning and decision making at the regional and national levels.

(d) *Curricula renewal:* Universities/institutions should consider curriculum development at par with teaching and research for purposes of evaluation of teachers' performance; all curricula should be reviewed and revised at regular intervals. There should be provision for introducing new topics in emerging fields with full consultation with local industries and industry associations. Institutions should prepare students for life-long learning and problem-solving competencies and sensitize students to problems of social concerns through appropriate curriculum and project work.

(e) *Program flexibility*: Academic programs should be designed to provide maximum flexibility to students to select courses according to their felt needs. Universities and institutions should permit transfer of credit from one institution/university to another, subject to a maximum specified limit.

(f) *Student evaluation:* A system of continuous evaluation of students' progress and performance for every course should be incorporated in the curricula of all institutions. Teachers should be expected to develop parameters for judging the analytical, innovative and problem-solving abilities of students and to diminish the emphasis on memory and retention testing. This will require training and support.

(g) *Self assessment:* Each institution should publish annually its academic achievements including data on the employment of graduates for information of its management, government, UGC/AICTE and the employees and these can be displayed in Internet or such electronic media which can be accessed by students and parents.

5.4 While deciding on the course of action for reforms, India could learn from the experience of developed and developing countries, where the higher education is undergoing major reforms. Annex 3, extracted from the Bank's sector report on higher education in China and OECD documents (Refs. 21, 22) lists some of the reforms undertaken by the OECD and some transition economy countries.

C. Closing Remarks

5.5 With its long history and tradition of seeking and disseminating knowledge, India can and must build on its existing wide base of higher S&T education. After an enthusiastic and quality-driven beginning after Independence, there is a noticeable decline in the quality of education due to its rapid growth, excessive but ineffective controls, and diminishing resources. However, there is strong policy support from the Government; the system admits only selected students; faculty is dedicated; there are models of successful institutions. There is also strong support for R&D and increasing interest in private industry for new technology.

5.6 Building on its strengths and recognizing its weaknesses, it is possible to turn the situation into an opportunity and make the higher S&T education system to be one of the best in the world. This will, however, need major strategic reform in governance, financing and quality assurance mechanism, one that empowers individual educational institutions to respond to local opportunities with respect to student demand and labor markets. It will need the dedicated participation of all stakeholders. This is most urgent, if India with over 700 million people below the age of 35 years is to progress, against all internal and external pressures, as a democratic nation capable of providing a decent quality of life to all its citizens.

Table 2: Summary of Issues, Strategies and Recommendations

A. AUTONOMY , EFFECTIVENESS AND ACCOUNTABILITY			
ISSUES	**STRATEGY**	**RECOMMENDATIONS**	**IMPLEMENTING AGENCY**
1. Centralization leading to lethargy in decision making in introducing improvement, and in attenuating initiative of faculty members and institutional managers. 2. Lack of institutional accountability for academic work; lack of Performance Audit	1. Empowerment of institutions 2. Freedom to experiment on academic, managerial and financial innovations 3. Tightening Monitoring and Evaluation mechanisms 4. Institution of rewards for meritorious work of teachers and employees 5. Financial incentives award for improving functional and academic efficiency	. All tertiary education institutions to enjoy academic, administrative and financial autonomy in varying degrees. Fully developed institutions to have full autonomy, while others grow into full autonomy status through graded stages depending on their level of competence; performance audit at every stage. . All tertiary institutions to have an Advisory Board composed of a mixture of industrial, academic and civic leaders and especially alumni to guide the philosophical development of the institution and offer advice . A system of periodic assessment of all teaching/research programs be established and reports made available to the Head of Institution and the Advisory Board for making desirable changes. . To place greater pressure in favor of autonomy, UGC to provide special financial incentives, and international agencies to prefer autonomous institutions for support. . Govt./UGC should introduce an annual performance audit of all institutions, grants be based on performance. . Each Institution should publish its academic achievements including the employment of graduates on an annual basis for information of its management, government, UGC/AICTE and the public. . Government/UGC should institute awards for meritorious work, innovations and improvement of Institutional efficiency. These awards be on competitive basis.	UGC, AICTE, Central/State Governments Private management Heads of institutions and their management Heads of institutions and their Management UGC International Agencies Govt./UGC/Management All institutions Govt./UGC
B. RESOURCE MOBILIZATION AND UTILIZATION			
1. Dwindling government grants to higher S&T education; other sources of funding not tapped 2. Large wastage of resources 3. Limited private	1. Mobilization of resources from all stakeholders including Govt. departments, industry and other beneficiaries 2. Networking of institutions, government laboratories, industry for optimizing resource utilization; 3. Reduction in fragmentation of	. Government to set up a S&T Education Fund both at the Center and State level; all socio-economic ministries of the Govt. to set aside 2% of their development budget as their contribution to higher education fund. . All science departments of the central government to introduce specific schemes for development of science laboratories in selected institutions. . Industry and individuals contributing to the S&T Education Fund be given attractive tax incentives. . Student fees for courses be based on real cost and market forces with a provision for scholarships/loans to deserving poor students.	Central/State Governments Central Government (Science Departments) Central Government (Ministry of Finance) Institute Management

investment except in professional courses	resources and minimization of all forms of wastage 4. Increased private participation	. Endowment funds to be raised with contributions from industry, charitable trusts, industry and alumni, and earnings from limited commercialization of facilities, consultancy and continuing education programs, exploitation of patents and other intellectual property rights; government to give matching grants to the endowment fund as an incentive . Local, regional and national networks be set up among institutions, government laboratories, industrial laboratories and other knowledge producers for an optimal utilization of infrastructure as well as intellectual/ knowledge resources of individual network institutions; joint post graduate programs, research and consultancy, and joint membership of complex problem-solving teams be encouraged. . Introduce strict assessment of available resources and competence before establishing any public-funded new research institution so that financial intellectual resources are not fragmented further . Allow no new programs of study for which incremental funding is not assured for at least five years.	Institute Management, Central/ State Govt. Central/State Governments UGC Institute Management Government of India UGC/AICTE
C. MAINTENANCE OF QUALITY & QUALITY ASSURANCE MECHANISMS			
1. Conflict between merit and social issues in selection of students 2. Inadequate number of trained teachers in S&T education 3. Inappropriate modes of instruction; outdated curricula; inadequate R&D 4. Poor linkage with users 5. Rapid expansion 6. Brain drain	1. Affirmative action emphasis in school education and financial incentives to students from disadvantaged group admitted on merit 2. Incentives for study leave for higher education to teachers with proven ability 3. Setting up of curriculum development centers 4. Strengthening academic staff colleges 5. Strict monitoring of quality, efficiency and effectiveness 6. Development of schemes for attracting migrants back to India	. Governments to assist through formal mechanism school graduates belonging to disadvantaged groups so that they can compete on merit. . Teachers of proven merit be encouraged to study for higher degrees on part-time/full-time study leave from the institution. . The existing Academic Staff Colleges in universities be strengthened and more opened for upgrading teachers' competence in their individual areas of specialization, education technology and use of I.T. tools . Each university/institution be required to collaborate with others in the region for developing curricula and learning materials in different subjects for use of students. Regional/national Centers be established to monitor progress of individual centers and to store output from them for national dissemination. . UGC/AICTE to strengthen their accreditation mechanism and make accreditation mandatory (not voluntary as at present) . Institutions to give preference to problem solving multi-disciplinary research activities and reorganize research teams on that basis. . UGC/Management to provide incentives to institutions for increasing efficiency and effectiveness. . UGC/AICTE to encourage non-resident Indians holding professional appointment in foreign universities to spend their sabbatical leave in India	Central/State Governments UGC/AICTE Institute management UGC/AICTE UGC/AICTE Institute management UGC/AICTE Institute management UGC/AICTE Institute management UGC/AICTE

D. TECHNOLOGY/ INFRASTRUCTURE SUPPORT			
1. Inadequate access to information and delivery systems for information 2. Educational Technology support for diffusion of knowledge extremely inadequate 3. Library support for books and journals very insufficient	1. Extensive use of I.T. tools for collection, storage and dissemination of information 2. Proper management information system for quick decision making and optimizing resource mobilization 3. Networking of library services with better endowed institutions. 4. Setting up of Educational Technology Centers.	. A separate fund be provided to all higher educational institutions to computerize their academic and personnel records, financial management, registration, admission, course allocation, library accession and circulation, and for developing a suitable support for management decisions. . A local area network be set up to share information by all concerned; students and teachers be given access to Internet facilities and international databases; access to computing facilities be available round the clock. . Library networks be established on local/regional/national basis. . Each institution of higher learning be equipped with an education technology center for preparing video lectures and for training in micro-teaching. ET tools, audio video, virtual laboratories, virtual fault diagnostics, and virtual design be used extensively in teaching; and equipment well maintained.	UGC/AICTE Institute management Institute management UGC/AICTE Institute management
E. ACCESS & EQUITY			
1. Limited access 2. Affirmative action without sacrifice of merit. 3. Limitation of funds for expanding access 4. Regional imbalance of opportunities for S&T Education	1. Expand distance education. 2. Encourage larger private investment in S&T higher education, particularly to remove regional imbalance. 3. Experiment with Net –Varsity, External University concepts with proper quality control. 4. Enable teacher/student mobility from one institution to another, one region to another. 5. Develop self-learning packages and competency based certification of self-learning. 6. Develop merit-based affirmative action schemes to enhance participation of women, SC&ST, and disabled persons.	. Every large State to have at least one multi-disciplinary Open University access to which could be universal but based on merit of the individual. The Open University may also be empowered to run Net-varsity through computer network. . Fiscal incentives be provided for establishing institutions of higher education in under-developed areas. Such institutions be networked with good institutions to ensure quality. . Introduce Credit System in all instructions of higher education and permit Credit transfer between institutions. . UGC/AICTE to establish centers for development of learning materials with emphasis on self-learning. They should also develop scientific criteria for evaluation of self-learning and issuance of competency based certificates. . Incentive packages be developed to encourage disadvantaged groups to join higher education strictly on merit basis.	State Government Central Government UGC/AICTE, State Universities, AIU UGC/AICTE Central & State Governments

ANNEX 1

CURRENT STATUS OF SCIENTIFIC AND TECHNICAL MANPOWER DEVELOPMENT IN INDIA

A. Introduction

1. India has a long history of education and teaching of pure and applied sciences, dating back to over 2600 years ago. One of the first universities in the world was established in India in the 6th Century BC at Takshila (Ref. 14). Major fields of study included mathematics, biology, medicine and astronomy. Knowledge of metallurgy and architecture was also quite advanced for that time. Unfortunately, much of this glory was lost during the medieval period. During the 19th century, a few western type universities were established. Most of them were established through individual efforts, a few were based on community efforts. Some of these achieved world-class quality. Recognizing the value of science and technology for economic development, major emphasis was laid again on higher education and science and technology after Independence in 1947. Today India possesses Asia's oldest, largest and most diverse infrastructure for scientific and technical education and training, and it has made important contributions to the country's scientific and industrial development. Thousands of graduates produced by the system are also now a part of professional manpower in the developed countries.

2. During the last fifty years, there has been a phenomenal growth in higher education in India. In 1950-51, only 263,000 students were enrolled in some 750 colleges affiliated to 30 universities. Total post-secondary enrollment in 1998 exceeded seven million students in university departments and some 9700 degree colleges affiliated to 229 universities (or equivalent institutions), and over 9.5 million students in over 6500 below-degree institutions (Ref. 11-13). The enrollment in higher education is currently growing at a rate of about 5.1% per year. However, student registration for degree programs in sciences has declined from 32% of the total in 1971 to less than 20% now. The student intake for engineering is growing fast but it still accounts for only 5% of the total enrollment in degree courses.

3. In spite of very significant expansion of higher education in the country during the last five decades, only 6% of the relevant age group of 18-23 years are enrolled for higher education. This is well below the norm of about 30-40% for developed countries and lower than the percentage for several developing countries.

4. Of all students in higher education, about 36.6% students are women, with the highest percentage of women students being in Kerala (53.6%) followed by Punjab (51.5%) (Ref. 11,12). Their participation in technical education has also shown a three-fold rise in recent years due to increased government policy support (e.g., reservation of seats for women in some states, granting of scholarships, provision of hostel facilities, support of a World Bank assisted Technician Education Project in India – Ref. 23). To help uplift weaker sections of the society, most state governments have also reserved up to 50% of the seats in all public institutions for scheduled castes/scheduled tribes and other backward classes.

5. Expansion of the quantitative capacity of India's post-secondary training systems has been accompanied by a decline in quality, exacerbated in recent years by declining public expenditure on the one hand, and an inadequate policy framework for private provision and financing on the other. Over 70% of the colleges lack basic facilities of laboratories, libraries and computer systems for quality education at the undergraduate level. Many universities today have no funds to support any research. The following sections briefly discuss the structure of India's higher education system, its governance and financing, its relationship with the labor market, and possible directions of growth with reference to technical and scientific education. The system's strengths and weaknesses, and the major issues are discussed in the main text. The existing policy framework supporting the system is discussed in Annex 2.

B. Structure and Characteristics of S&T Education and Training

6. India has a large and rather complex higher education system. The system comprises, at the apex level, the following institutions with the authority to award degrees:

- Universities established by the Government of India/State Governments through Act of Parliament or State Legislation;
- Institutes *deemed* to be universities by the UGC; and
- Institutes of national importance.

As of 1997-98, there were 179 universities, 11 institutes deemed to be universities and 11 institutes of national importance (Ref. 13).

7. Universities can be either 'unitary', conducting all programs through its academic departments (and constituent colleges, if any) in the same campus (or city); or an 'affiliating' university with academic colleges spread over a region and affiliated to it. Typically a University comprises 6-8 academic faculties with 40-60 affiliated colleges. Some of the larger universities like Calcutta, Bangalore, Osmania and Bombay Universities have over 250 affiliated colleges each. As of 1997-98, there were over 9700 colleges affiliated to universities – the majority of them offering only undergraduate courses. Table 1.1gives the regional distribution of higher education facilities in India. The states covered under each region are also indicated.

Table 1.1: Higher Education Institutions in India

Region	No. of University Level Institutions	No. of Colleges	Students Enrolled (in Thousands)
Northern	67	2007	2150
Southern	61	2878	1410
Eastern	48	2136	1750
Western	53	2682	1690
All India	229	9703	7000

Source: Based on information given in MHRD Selected Educational Statistics (1997-98); University Grants Commission Annual Report (1996-97) and the University Handbook, Association of Indian Universities, 1997. (Note: there is variation in the enrollment data in different documents.)

Northern Region: Delhi, Himachal Pradesh, Haryana, Jammu & Kashmir, Rajasthan, Punjab, Uttar Pradesh, and Chandigarh.

Eastern Region:	Arunachal Pradesh, Assam, Bihar, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tripura, and West Bengal.
Western Region:	Goa, Gujarat, Madhya Pradesh, Maharashtra and Daman.
Southern Region:	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Pondicherry, and Andaman & Nicobar.

8. Institutes not covered under or affiliated to the three categories of institutions noted above can only offer diplomas or certificates, which are recognized for employment at appropriate levels. For example, the post-graduate Diploma of the Indian Institutes of Management is considered equivalent to a Master's degree in Management/ Business Administration. On the other hand, a Diploma after a two or three year course from a polytechnic is a below-degree level qualification for technicians.

9. Open universities (notably, Indira Gandhi Open University) and some professional bodies (notably, the Institution of Engineers (India), and Institution of Electronics & Telecommunication Engineers) are making important contributions to the development of technical and scientific manpower through distance education and coaching programs and by conducting examinations for different levels of qualifications. The main beneficiaries are persons already employed who wish to improve their qualifications. Every year, a few thousand persons qualify from these programs. However, this mode of education and training has not been exploited fully.

Higher Education in Sciences

10. Higher education in sciences in India is almost completely conducted by university departments and some 5000 government/government-aided colleges and by the open universities. Due to lack of demand, private sector participation is limited only to managing the institutions with significant financial support from government. Unlike in engineering, none of the professional bodies and Academies of Sciences (there are three Academies) conduct any programs leading to qualifications.

11. Students are admitted to science degree programs after completion of senior secondary education (12 years). Bachelors' degree in science is awarded after successful completion of a three- year program. Normally, a student studies three subjects in all the three years for a general degree in science. Some universities award a degree with honors which requires one subject to be studied in depth as a principal subject. A Masters' degree in most science subjects needs two years of studies. Most universities require completion of a 12-18 months M.Phil. program before registering them for a Doctoral program in a science faculty.

12. Indian universities offer a range of courses in pure and applied sciences. While most offer courses in the traditional subjects of Physics, Chemistry, Botany, Zoology, and Mathematics, some have introduced courses in geo-sciences, environment science, microbiology, biotechnology, energy sciences, information technology, applied electronics, and material science. At the Masters' degree level some universities offer several specialization. Reference 13 lists the courses available in the universities.

13. Amongst traditional courses, while Physics, Chemistry and Statistics continue to attract students, there is a noticeable fall in the number of students wanting to study

Mathematics, Botany, Zoology and Geology (Ref. 14) due to limited career opportunities. On the other hand, there is high demand for courses in such emerging areas as information technology, biotechnology, digital electronics, etc. The main constraints in introducing new courses in colleges have been the limitation of resources and the lack of qualified teachers. Another problem has been a very rigid curricula structure with little choice of subjects left to the students. Also, due to the long procedure involved, curricula are not updated for years in many universities.

14. The total stock of qualified scientific and technical manpower in India in 1997 was estimated by the Institute of Applied Manpower Research (IAMR) (Ref. 11) to be about 6.5 million. This included 1.1 million engineering diploma holders, 0.73 million engineering degree holders, 3.3 million science graduates, 0.66 million science post-graduates and 0.7 million other professionals. The system is producing an impressive number of degree-holders every year (estimated to be about 190000, 38000 and 3800 at B.Sc., M.Sc. and Ph.D. levels, respectively). However, there are high dropout and failure rates (over 40%) at the under-graduate level. Many students take an additional one to three years to complete the first degree. Further, due to limited job opportunities and inadequate exposure to challenges in science during their studies, a large percentage of graduates do not pursue science as a career. It is not surprising in India to find science graduates working as office assistants. These facts reflect poor system efficiency and low quality and relevance of science education at the under-graduate level in many universities.

15. In research and post-graduate education in pure and applied sciences the Indian Institute of Science, Bangalore, and a few university departments have maintained international standards. However, most universities and colleges are far behind the frontiers of science and technology. Despite the availability of qualified staff in several disciplines, most colleges do not have any activity worth the name in research and development. As a result, graduates are not prepared or attracted to science or R&D as a career. Contrary to popular belief, per capita availability of personnel engaged in scientific and technical activities in India is extremely low (Table 1.2).

Table 1.2: Scientific Manpower: A Comparison

Country	Scientists & Technicians (per 1000 population)	R&D Scientists & Technicians (per 1000 population)
Brazil	29.5	0.2
China	8.1	0.6
Germany	86	4.0
Israel	76	5.9
Japan	110	7.1
Korea	45.9	2.9
USA	55	4.0
India	3.5	0.3

Source: Human Development Report 1994, 1998 UNDP; data corresponds to 1990-96 (Ref. 24)

16. Scientific R&D activities in India are largely confined to national research laboratories established by the Government of India. Barring a few exceptions, these laboratories have no links with academic institutions.

Higher Technical Education

17. Institutions offering formal programs in engineering and technology in India may be broadly classified (Ref. 8) as follows:

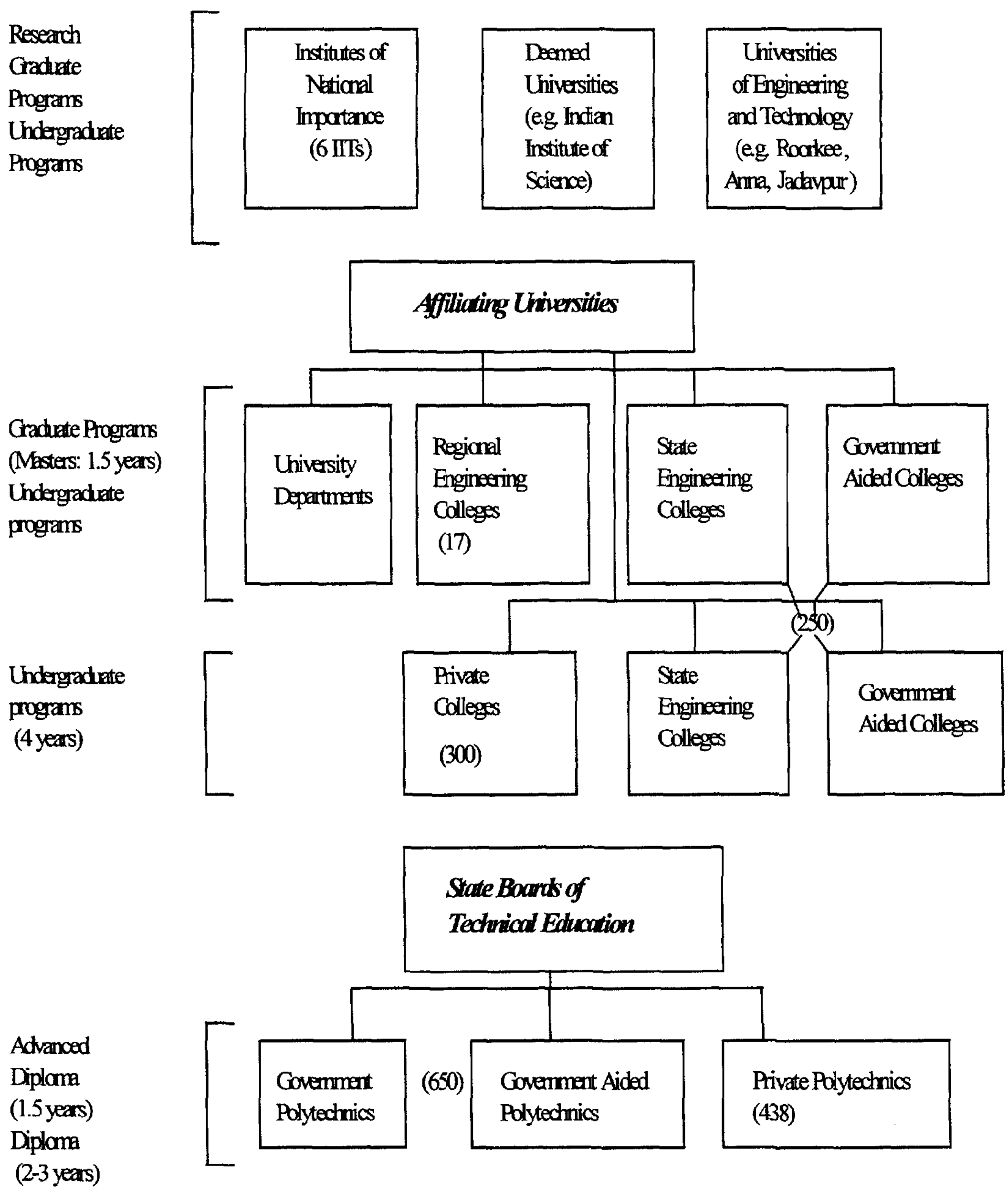
- Institutions of national importance (e.g., Indian Institutes of Technology)
- Technical Universities (University of Roorkee, Anna University, etc.)
- Institutions deemed to be Universities (Indian Institute of Science)
- Regional Engineering Colleges (established jointly by Government of India and state governments) – affiliated to universities
- University Departments/Colleges
- State engineering colleges/government aided colleges – affiliated to universities
- Private (self-financing) colleges – affiliated to universities
- Government/aided Polytechnics (offering diploma programs under State Boards of Technical Education)
- Private (self financing) Polytechnics (offering diploma programs under State Boards of Technical Education)

18. At the apex of the technical education institutions in the country are the Indian Institutes of Technology (IIT) established by the Government of India, one in each region: North (Kanpur), South (Chennai), East (Kharagpur), and West (Mumbai). Besides these, one IIT has been located at Delhi since it is the national capital. Another IIT is in the early stages of development at Guwahati to cover the needs of the North-Eastern region. These institutions have been established with some international technical cooperation and have developed themselves to be amongst front ranking institutions globally. India also has some front ranking exclusive universities/institutions for engineering and applied sciences education. These include the Indian Institute of Science, University of Roorkee, Jadavpur University, and Anna University.

19. The Government of India has also established, in partnership with the states, 17 Regional Engineering Colleges (RECs) with a primary focus on high quality engineering practice. These colleges along with about 30 well-established state colleges and government-aided private colleges form the second tier of leading technical institutions. Unfortunately, these institutions suffer from multiple controls and limited resources and are far behind the IITs in their overall development.

20. The RECs are followed by some 500 government/government-aided and self-financing engineering colleges offering only degree programs and some 1100 polytechnics offering diploma programs. Most of these institutions operate under strict control of the State Directorates of Technical Education and the affiliating universities or State Boards of Technical Education.

FIGURE 1.1: TECHNICAL EDUCATION INSTITUTES IN INDIA

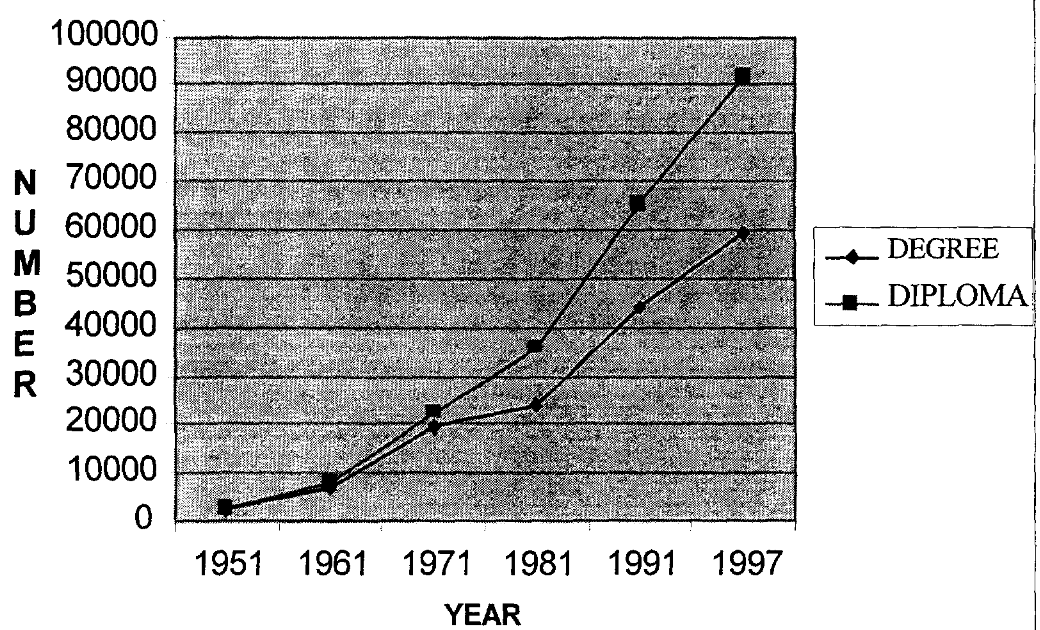


21. Students are admitted into engineering degree programs after completion of senior secondary (12 years) education. Completion of a Bachelor's degree in Engineering or Technology needs four years, and a Master's in Engineering one and half year thereafter. Some institutions offer a five year integrated program leading to a Master's degree in engineering. The minimum qualification for admission into an engineering diploma program of 3-year duration is generally secondary education (10 years). Due to heavy

demand most institutions admit students for degree programs after a national or state level entrance test.

22. Figure 1.2 illustrates the growth over the past 50 years in the number of graduating students from technical institutions. The formal technical education system is currently producing about 65,000 degree-holders and 95,000 diploma holders every year. The dropout and failure rates are moderate. However, a significant percentage of degree holders from better institutions take-up management and administrative jobs or go abroad. The loss to non S&T jobs and emigration is reported to be as high as 40-50% in some critical areas of technology (e.g., information technology, bio-technology, micro-electronics) from the IITs and a few other institutions.

FIGURE 1.2: GROWTH IN THE NUMBER OF GRADUATING STUDENTS IN ENGINEERING AND TECHNOLOGY



23. Unlike the very high demand for a graduate degree in engineering, over 60% of some 19,000 seats approved in 191 institutions for post-graduate education in engineering colleges remain vacant and less than 7,000 students per year complete the courses. Annually less than 400 research scholars complete their Ph.D. in engineering and technology. Currently over 60% of the seats for doctoral programs in engineering at IITs are lying vacant. The low enrolment in post-graduate and research programs in engineering is partly due to a lack of interest but mainly due to the very limited number of candidates qualifying for admission to post graduate programs through GATE (Graduate Aptitude Test for Engineering) - a national level test. *The consequent low output of postgraduates, the main source of supply of teachers, is a major cause of concern for the technical education system, which already suffers from about 10,000 vacant positions.*

24. Many institutions have little or no contact with industry or the service sector. Due to political and social pressures some institutes are also located in areas far away from any industrial activity. The emphasis is on theory adequate for passing examinations conducted by the affiliating university or the state Board of Technical Education. Students and teachers have little exposure to practice. Graduates from these institutions are consequently required to be trained again by industry over an extended time before they become productive in industry.

25. There is a very large regional variation in the available facilities in professional education. Based on the 1996 data (Ref. 6,8), the following region-wise distribution is obtained for engineering education:

Table 1.3: Regional Distributions of Seat Capacity in Engineering

Region	Population (%)	Seat Capacity (%)	
		Degree	Diploma
Northern	28.70	11	25
Eastern	25.77	07	15
Western	22.18	31	29
Southern	23.35	51	31
Total	100	100	100

Note: See Table 1.1 for definition of regions.

26. The status of distribution of seat capacity in 1996 (Ref. 6,8) for some states having more than 44 million population is given below. There is large disparity between states. The states of Karnataka, Maharashtra and Tamil Nadu, which have encouraged establishment of self-financing private colleges, are far ahead of others in engineering educational facilities. With the recent approvals of many new institutions in the private sector in other states, this disparity is expected to reduce.

Table 1.4: State-wise Distribution of Seat Capacity for Engineering Degree

States	Population (000's) (1991)	Capacity per 10,000 Population
AP	66508	1.25
Bihar	86374	0.27
Gujarat	41310	0.83
Karnataka	44977	**5.0**
MP	66181	0.34
Maharashtra	78937	**3.3**
Rajasthan	44006	0.37
Tamil Nadu	55859	**3.3**
UP	139112	0.23
West Bengal	68078	0.29

27. With the growing demand for professional education on the one hand and the government shifting its focus to primary education on the other, there is *growing participation of the private sector* in technical and medical education. The following table indicates for private sector participation in various states in technical education:

Table 1.5: Number of Technical Institutions (Degree & Diploma) in 1997-98

A. B. States	Number of Institutions Degree	Diploma
Andhra Pradesh	57 (48)	82 (20)
Assam	3 (0)	9 (0)
Bihar	12 (3)	29 (3)
Delhi	5 (0)	26 (12)
Gujarat	19 (8)	38 (3)
Haryana	20 (12)	29 (5)
Himachal Pradesh	2 (1)	7 (1)
Karnataka	69 (57)	190 (140)
Kerala	19 (2)	52 (3)
Madhya Pradesh	28 (10)	49 (1)
Maharastra	112 (88)	165 (103)
Orissa	18 (11)	25 (12)
Punjab	14 (4)	38 (7)
Rajasthan	10 (4)	27 (5)
Tamil Nadu	106 (89)	175 (117)
Uttar Pradesh	41 (14)	106 (3)
West Bengal	14 (2)	41 (3)
Total	**549 (353)**	**1088 (438)**

Source: All Indian Council for Technical Education (AICTE).
Note: Numbers in brackets indicate the number of self-financing private institutions.

28. The number of technical institutions is increasing rapidly as the AICTE has been liberal in approving the establishment of self- financing institutions. A few cities now have several private engineering colleges, each competing to get a share of the market. *A major problem faced by these institutions, as well as by the government colleges, is non-availability of qualified, experienced staff, particularly in newer technology areas.* Many institutions are operating with part-time/ad-hoc appointees who join a college temporarily till they get a decent job in industry. Staff shortages, combined with a lack of adequate library facilities, workshops and laboratories are affecting the quality of education adversely.

C. Governance and Financing of Scientific and Technical Education

29. *Scientific and technical educational institutions in India are subject to multiple levels of governance and control and to a complex procedure of financing.* At the highest level the Government of India (GOI) is responsible for co-ordination and determination of standards in institutions for higher education and research and scientific and technical institutions. This responsibility is handled primarily through the Department of Education in the Ministry of Human Resource. The University Grants Commission (UGC) and the All India Council for Technical Education (AICTE), established by Acts of Parliament, have the statutory responsibility of promoting, regulating and maintaining standards in general higher education (including science) and technical education, respectively. The Planning Commission plays the deciding role in all developmental funding under the Union Budget prepared by the Ministry of Finance and approved by the Parliament. Funds are released through the Dept of Education/UGC/AICTE. Funding of schemes/programs beyond certain specified limits requires approval of the Union Cabinet of Ministers.

30. At the state level, universities come under the purview of the Department of Education (or Higher Education in some states) which is responsible for planning and maintaining all higher educational institutions. In many states there are separate departments and directorates which handle technical education. All operational funds and some developmental funds are released to the institutions by the Department with the concurrence of the Finance Department of the State. Most universities receive funds mainly from the state department, and some receive development grants from the UGC. Government and Government-aided colleges and polytechnics receive funds through the Directorate of Education/Technical Education. The heads of institutions spend a significant part of their time preparing documents and in following up actions to get the budgeted funds released to them.

31. Generally universities also follow very rigid rules in all administrative, academic and financial matters in governing their departments or faculties and affiliated colleges. *Very large universities with numerous colleges face major problems of governance and maintaining standards.* Any changes or revision of curricula and introduction of any new programs or innovations are very difficult due to lengthy process of formal approval. The universities are often subjected to political interference and court rulings in addition to internal pressures from agitated students, faculty and staff.

32. In addition to the university rules, colleges affiliated with the universities have their own rules and regulations. Most government colleges have little control over admissions, appointment of faculty or other staff, program design, academic timetable, curricula, evaluation methodology, examination or procurement of goods and works. These are all decided and controlled by state directorates or the university administration. Private self-financing institutions have a little more freedom in all matters except curricula and examinations, which are centralized at the university or state directorate levels. This has a direct influence on the program ownership and commitment of the faculty involved.

33. These excessive sets of controls meant to maintain standards and accountability have in fact introduced major inertia in the system, and the system is now unable and sometimes unwilling to respond to needs of the students, society and labor market. The centralized entrance tests have become stereotyped and can easily be trained for which militates against creative thoughtful students. The syllabi and courses are often tied down by centralized rigidity and a lack of imagination. Even where teachers are willing to change, the system will not permit experimentation. The system takes too long to respond to any suggestion or request. Examinations have become a ritual and have lost their sanctity in many places due to mal-practices. In most places, the emphasis has shifted from learning and acquiring skills to passing an examination. This has also resulted in an over-emphasis on theory at the cost of practice, even in the case of polytechnics.

34. Higher education in the sciences is almost entirely dependent on government funding, technical education is also still largely dependent on government support. The following table (based on data in the IAMR Handbook, 1999 – Ref. 11) indicates that the Government of India and state governments spend about 3.6% of its GDP on education against the stated goal of 6%. Of this expenditure, higher education and technical

education have a share of about 16.4%. This translates into an average annual expenditure of about Rs. 11,800 (US$300) per student. There is a large variation (ranging between Rs. 5,000 to Rs. 100,000 per student per year) in actual expenditure depending on the course and institution. At present, the fee income in most public institutions varies from 2% to 7% of the operating cost.

Table 1.6: Government Expenditure on Education in India and Percentage Distribution of Education Expenditure for Different Levels

	1970-71	1980-81	1990-91	1995-96
GDP (Rs. in million)	397,090	1,224,270	4,778,140	10,062,860
Govt. Expenditure on education (Rs. in million)	11,180	36,410	207,610	392,990
Education Expenditure as % of GDP	2.82	2.97	4.34	3.91
Percentage Share of Elementary Education	44.9	48.5	43.8	47.3
Secondary Education	31.3	32.3	30.5	31.7
Higher Education	9.3	12.2	13.2	12.1
Technical Education	3.8	2.8	4.8	4.3
Others (Adult education, etc.)	10.7	4.2	7.7	4.6
Number of Degree and above Students (million)	2.02	2.9	4.57	5.37

Source: Manpower Profile India- Year Book 1999, Institute of Applied Manpower Research; Ministry of Human Resources Development, Analysis of Budgeted Expenditure on Education. (Ref.16)

35. *Most of the funds available in higher and technical education are currently spent on operation of the existing system.* After paying for salaries and essential services hardly any money is left for capacity building or quality improvement. Government of India provides some funds for this purpose through its Five-Year Plans. It is seen from the following table that with the increasing focus of the union and state governments on primary education, the share of higher education in the plan budget for education has declined drastically from 25% in IV Plan to only 8% in VIII Plan. This small fund available is again largely being utilized for central elite institutions and for establishing new institutions, leaving indeed no development or R&D funds for most colleges and universities.

Table 1.7 : Share of Central Plan Expenditure on Different Sectors of Education

	IV Plan (1969-74)	**V Plan** (1974-79)	**VI Plan** (1980-85)	**VII Plan** (1985-90)	**VIII Plan** (1992-97)
Total Expenditure (Rs. in million)	7,860	9,120	25,300	76,330	196,000
Percentage Share of Elementary Education	30	35	33	37	47
Secondary Education	18	17	21	24	18
Higher Education	25	22	22	16	8
Technical Education	13	12	11	14	14
Others (Adult education, etc.)	14	14	13	9	13

Source: Department of Education. (Ref. 16)

36. All public colleges and universities in India are facing a financial crisis due to very limited and delayed release of funds and due to limitations on their ability to mobilize other resources. Further *a major part of any revenue generated by public colleges and polytechnics is adjusted against their approved budget.* The Government and aided institutions, therefore, have no incentive to mobilize any revenue. While the operating expenses have gone up several fold due to periodic revision of salaries and cost inflation, the fee structures in most universities and government colleges has remained unchanged for over 30 years. Salaries, fee structures and admission criteria are specified by the UGC and AICTE. In order to avoid any undue exploitation of the demand for professional education by private promoters, the Supreme Court of India has also laid down certain guidelines for fees and admissions. However, *a significant percentage of private institutions, established as a business activity for profit, do not meet the specified minimum norms of faculty and infrastructure.* These observations are confirmed by a sample study.

Findings of a Sample Study on Financing of Technical Education

37. A survey undertaken in 1998 as a part of the present study (Ref. 10) covered 70 self-financing private engineering colleges, 8 government engineering colleges, 11 Regional Engineering Colleges, 4 IITs, 85 private polytechnics and 92 government polytechnics in different regions of the country. The main findings of the study are listed below:

(a) Private participation has penetrated well into engineering education. A large number of private engineering colleges and polytechnics provide education with the income from fees. However, their freedom is restricted as the AICTE specifies ceiling on their fees and admissions, and intakes are decided by the state Government. A significant percentage of their seats (called free seats) are filled by the state on a nominal fee basis. The rest are filled on a full-cost basis as determined from time to time by the AICTE.

(b) Government institutions charge a nominal fee, amounting to less than 5% of the operating cost in most cases. Recently, IITs and some RECs have begun to charge fee closer to 15% of the operating costs. IITs are also mobilizing resources from other sources and developing endowment funds to make the institutions more self-reliant.

(c) Salaries form the largest part of the operating cost, ranging between 60-80%. After paying for non-salary operating expenditures (water, power, transport, furniture, etc.), many institutions spend as little as 6% on teaching material and student welfare (books, equipment, consumables, scholarships, etc.) against the AICTE norm of 14-15%. These facts are presented in Table 1.8. For comparison, the corresponding average data for RECs and IITs is also indicated.

Table 1.8: Operating Expenditure Break-up in Percentages for Engineering Colleges

State	Number of Institutions Responding	Salaries	Teaching Material & Student Facilities	Other Expenditure
Andhra Pradesh	7	76%	10%	14%
Karnataka	12	74%	6%	20%
Maharashtra	32	61%	6%	33%
Punjab	3	79%	5.5%	15.5%
Tamil Nadu	15	59%	16%	25%
Regional Engineering Colleges (average)	11	72%	8%	20%
Indian Institutes of Technology (average)	4	50%	16%	34%

(d) *Wastage:* The opening of a large number of institutions with poor facilities and a lack of qualified faculty has resulted in significant wastage (failures, dropouts, seats remaining unfilled, etc.). The survey found that in Tamil Nadu, Maharashtra and Karnataka the wastage was as high as 33%, 30% and 23%, respectively. In polytechnics, wastage in Karnataka, Maharashtra, Andhra Pradesh was even higher at 58%, 42% and 29%, respectively.

(e) *Savings in private colleges from fee income:* Most colleges are now charging fees as per the AICTE guidelines. However, many are not following the norms specified for teaching material and students' amenities and for the level and quality of teaching staff. As a result, most private colleges seem to make a significant saving from the fees collected by them. The following table from the sample study indicates a significant percentage of colleges with savings greater than 50% of the fees collected.

Table 1.9: Percentage of Private Engineering Colleges with Savings from Fee Income

State	Saving up to 20%	Saving from 21% to 50%	Saving more than 50%	Total
Karnataka	30%	20%	20%	70%
Maharashtra	25%	43%	18%	86%
Tamil Nadu	21%	43%	7%	71%

(f) *Unit cost*: Cost per student per year is an important indicator both for the institutional performance as well as the general economic efficiency of the system. There is a wide variation in this cost amongst government and private colleges. In the case of IITs, which provide quality education of an international standard, the unit cost works out to be Rs. 85,000 (US$2000) per student per year. In the RECs, it varies from Rs. 21,000 to Rs. 35,000 (US$500-$850). The AICTE has prescribed a norm of Rs. 16,800. However, *driven by the approach of saving and thereby not spending for the purposes most needed to provide good education, some colleges in the study had unbelievably low unit costs.* About 15% of the colleges in Maharashtra and Andhra Pradesh reported unit cost of only Rs. 6000 or less. The following table indicates the range of unit cost reported by the colleges sampled in 1998.

Table 1.10: Percentage of Private Engineering Colleges According to Range of Unit Cost

State	Up to Rs.6000	Rs.6001 - 10,000	Rs.10,001 - 15,000	Rs.15,001 - 20,000	Above Rs.20,000
Andhra Pradesh	14.2%	42.9%	42.9%	-	-
Karnataka	-	58.3%	16.7%	16.7%	8.3%
Maharashtra	15.6%	15.6%	50%	9.4%	9.4%
Tamil Nadu	-	20%	33.3%	13.3%	33.3%

(g) *Faculty composition*: The AICTE has prescribed norms for the student: teacher ratio and faculty composition and qualifications in engineering institutions. The survey shows a large variation amongst colleges and between states. The following table lists this variation, primarily in private colleges in major states. Maharashtra and Tamil Nadu, with a large number of private institutions, have a high percentage of teachers without any postgraduate qualification. For comparison, the data for RECs and IITs is also indicated. These large variations explain the difference between the levels and quality of education among engineering educational institutions in India.

Table 1.11: Faculty Composition in Engineering Colleges

State	Student/ Teacher Ratio	Teachers with Ph.D.	Post- graduate Teachers	Teachers with Degree only
Andhra Pradesh	15.6	17.5%	72%	10.5%
Karnataka	15	7.6%	66%	26.4%
Maharashtra	17.5	7%	48.9%	44.1%
Punjab	13.6	31.8%	44%	24.2%
Tamil Nadu	15.9	9.9%	55%	35.1%
RECs	11	43%	45%	12%
IITs	7.5	95%	5%	-

D. Labor Market for Engineers and Technicians - Results of a Sample Survey

38. The Structural Adjustment Programs initiated by the Government of India in 1991, as part of the economic reforms, have brought about a significant shift in occupational composition. This has demanded changes in the levels of knowledge and skill of the workforce in general, and engineers and technicians in particular. A study (Ref. 9) conducted in 1998, as a part of this study, by the Institute for Applied Manpower Research (IAMR) attempts to capture these changes in the labor market based on the data available in the National Technical Manpower Information System (NTMIS). To the extent necessary, the data were validated through discussions with the experts in the field and also through a sample survey of front line industrial establishments in thrust areas selected in consultation with the Confederation of Indian Industries (CII). In addition, the State of Karnataka was taken up for gathering information from the employing industrial units based on personal contact.

39. The IAMR study estimated and projected the stock of engineering degree and diploma holders, taking their estimated stock in 1995 as the benchmark. This estimation is based on the category-wise institutional outturn data of degree and diploma holders from 1960, assuming attrition rates due to mortality as 0.3% per annum and international migration as 1.2% per annum for degree holders. An average passed out rate (for each category of graduates) for 1985-91 was applied on the actual admissions during 1992-96, to estimate the corresponding outturn during 1996-2000. These figures were then added to the benchmark figures of 1995 for projecting the stock. In the projections, the retirement rate is assumed to be 0.2% per year.

40. The results presented in the following table show that in the core engineering disciplines, Mechanical Engineers constituted the single largest category in 1995 followed closely by Civil Engineers. Electrical Engineers came third while Electronics & Communication Engineers occupied the fourth position in the year 1995. However, by the year 2002, the stock of Electronics & Communication Engineers would occupy the 2nd rank, after Mechanical Engineers. The stock of Instrumentation Engineers is expected to register a seven-fold increase over the period 1995-2002 as result of the

recent expansion in the educational facilities for this category. Computer Engineering and Computer Applications are also showing very rapid growth.

41. At the diploma level, the stock of engineering technicians which was estimated to be 1,079,100 in 1995 is expected to reach a level of 1,559,580 in 2002, implying an annual growth rate of 5.4 per cent per annum. In 1995, Civil Engineering technicians (30%) were on the top of the list followed closely by the Mechanical Engineering technicians. Electrical Engineering came in third and though far behind, Electronics & Telecommunication the fourth. These four major categories accounted for 81% of the total stock of technicians in 1995. The stock of Electronics & Telecommunication and Computer Engineering technicians is expected to increase at a higher pace in comparison to the others in the four major categories.

Table 1.12: Stock of Degree Holders/Diploma Holders in Select Disciplines (1995-2002)

Degree Holders				Diploma Holders			
Discipline	**1995**	**1998**	**2002**	**Discipline**	**1995**	**1998**	**2002**
Aeronautical Engineering	1670	1770	1940	Agricultural Engineering	1770	1930	2210
Agricultural Engineering	3580	3930	4570	Automobile Engineering	19590	23010	28870
Architecture	12910	15560	20230	Chemical Engineering	9070	12070	17140
Automobile Engineering	1780	2170	2920	Civil Engineering	318790	356040	421210
Ceramics Technology	970	1080	1270	Computer Engineering	20270	33970	52330
Chemical Engineering	33770	38140	46070	Electrical Engineering	198170	222470	264870
Civil Engineering	151130	169820	202540	Electronics/Telecom	73040	106480	162640
Computer Engineering	30220	46870	67160	Hotel Management	3570	3680	3900
Electrical Engineering	105430	117260	138130	Leather Technology	2670	2780	2990
Electron./Telecom	78050	110100	164990	Mechanical Eng.	281610	322130	392320
Food Technology	970	1040	1160	Metallurgy	4520	5090	6090
Instrumentation	6260	18750	46600	Mining Engineering	8960	9700	11020
Leather Technology	770	830	930	Printing Technology	9660	10500	12010
Mechanical Engineering	166800	190540	231670	Production Engineering	5340	7300	10590
Metallurgy	14420	15170	16570	Textile Technology	22770	25680	30750
Mining Engineering	5640	6320	7590	Others	119570	146710	192970
Oil Technology	700	770	900				
Production Engineering	9730	13910	20970				
Sugar Technology	1290	1290	1310				
Textile Technology	8870	9520	10780				
Others	58470	80440	119070				
Total	**663210**	**798410**	**1040210**	**Total**	**1079100**	**1255570**	**1559580**

42. The survey results available in the National Technical Manpower Information System (NTMIS) covering more than 2000 industrial establishments show that *employment of engineers and technicians in private sector grew at an annual rate of 5.5 percent during the period from 1991 to 1995. However, in the case of public sector establishments, employment of engineers and technicians decreased by an annual rate of*

2.3 percent. Based on the trends of employment in different disciplines and certain realistic assumptions, the annual requirement of different categories of engineers and technician is projected in Table 1.13.

43. The table indicates that by the year 2002, degree holders in Electronics Engineering would be in huge surplus of over 54,000 if the admission to this course were maintained at the current level. Mechanical Engineers with degree would also be in significant surplus. Computer Engineering will continue to suffer from substantial shortage. Degree holders in Civil Engineering and Electrical Engineering, though estimated to be in small surplus in 2002, are expected to be in shortage soon afterwards. In respect of most other categories, a shortage situation is forecast. A situation more or less similar to that for degree holders is foreseeable for diploma holders.

Table 1.13: Estimates of Additional Requirements and Supply and Surplus/Shortage (-) for Select Engineering Degree and Diploma Holders in India (1997-2002)

Discipline	Degree			Diploma		
	Additional Need	Additional Supply	urplus/ hortage (-)	Additional Need	dditional Supply	Surplus / hortage (-)
Ceramics Engineering	579	342	(-) 235	452	322	(-) 130
Chemical Engineering	10629	13439	2810	2071	8675	6604
Civil Engineering	58156	61940	3784	107361	111144	3783
Computer Engineering	51264	35511	(-)15753	55310	27822	(-)27488
Electrical Engineering	34857	39526	4669	54732	76389	21657
Electronic Engineering	32188	86346	54158	22633	91183	68550
Leather Technology	321	285	(-) 36	1626	552	(-) 1074
Mechanical Engineering	51413	78126	26713	73069	123973	50924
Metallurgy Engineering	4821	3126	(-) 1695	1180	1754	574
Mining Engineering	3462	1794	(-) 1668	4695	4514	(-) 181
Paper Technology	303	162	(-)141	574	126	(-) 448
Petro-chemical Technology	272	168	(-) 104	742	144	(-) 598
Polymer & Rubber Technology	403	120	(-) 283	214	131	(-) 83
Sugar Technology	1064	402	(-) 662	161	54	(-) 107
Textile Technology	3687	2886	801	2778	3868	1090

44. *Pattern of employment and waiting period*: Under the NTMIS program, tracer studies are conducted regularly on an annual basis. According to the latest tracer study conducted in 1997 in Karnataka, over 20% of degree holders in Automobile Engineering, Chemical Engineering, Mechanical Engineering and Instrumentation Technology had to wait for three years for getting fully absorbed in jobs. In the case of diploma holders, even after three years the graduates of some of the disciplines like Chemical Engineering,

Electronics & Communication, Machine Tools and Mechanical Engineering could not get employment. However, there are certain new disciplines at diploma level (with limited intake) like Architecture, Cinematography, Costume Design & Dress Making, Instrumentation Technology, Polymer Science, and Sound & Television Engineering, the graduates of which got absorbed soon after completion of their studies. These results indicate a need for regular assessment and adjustment of programs to suit the market demands.

Table 1.14: Pattern of Annual Absorption of Degree and Diploma Holders in Karnataka

Level/ Discipline	*Annual Absorption in Percentage*			
Degree	**I Year**	**II year**	**III year**	**IV Year**
Architecture	97.0	3.0	-	-
Automobile Engineering	39.0	33.0	28.0	-
Chemical Engineering	44.0	36.0	20.0	-
Civil Engineering	51.0	30.0	19.0	-
Computer Science & Technology	65.0	22.0	13.0	-
Electrical Engineering	79.4	20.6	-	-
Electronics & Communication	67.7	32.3	-	-
Industrial Production	58.0	30.0	12.0	-
Instrumentation Technology	43.0	32.0	25.0	-
Mechanical Engineering	58.0	22.0	20.0	-
Metallurgy	66.0	34.0	-	-
Mining Engineering	100.0	-	-	-
Diploma	**I Year**	**II year**	**III year**	**IV Year**
Architecture	100.0	-	-	-
Automobile Engineering	54.0	30.0	16.0	-
Ceramics Technology	42.9	31.0	26.1	-
Chemical Engineering	30.0	24.0	24.0	22.0
Cinematography	100.0	-	-	-
Civil Engineering	40.0	33.0	27.0	-
Computer Science & Technology	43.0	33.0	24.0	-
Costume Design & Dress Making	100.0	-	-	-
Electrical Engineering	33.6	27.3	39.1	-
Electronics & Communication	49.5	27.9	14.6	8.9
Horological Engineering	55.0	25.0	20.0	-
Instrumentation Technology	100.0	-	-	-
Lithography	91.2	8.8	-	-
Machine Tool Engineering	50.0	26.0	14.0	10.0
Mechanical Engineering	43.0	21.0	21.0	15.0
Metallurgy	71.0	18.9	10.1	-
Mining Engineering	65.1	20.7	14.2	-
Polymer Science	100.0	-	-	-
Printing & Technology	48.0	52.0	-	-
Sound & Television Engineering	100.0	-	-	-
Sugar Technology	40.0	35.0	25.0	-
Textile Technology	59.6	20.9	19.5	-
Welding & Sheet Metal Technology	33.7	50.0	16.3	-

45. *Relevance of existing courses*: A survey of select industrial establishments in the front line areas was also conducted as part of the IAMR study (Ref. 9) with a view to identifying, among other things, the relevance of existing courses to the user industries in terms of basic skills needed for performing functions such as design, production, maintenance, quality control, materials management, R&D, project planning and execution and use of computers separately for the graduates of core disciplines and those in the new technology areas. Table 1.15 presents the normalized average of graded points for indicating relevance. Based on the procedures adopted, an index of 1.0 would indicate that relevance of courses for performing a particular activity is excellent, while an index ranging from 0.80 to 1.00, very good; 0.60 to 0.80, good; 0.40 to 0.60, fair; and less than 0.40, poor.

Table 1.15: Indices of Relevance of Skill to Industry by Level of Education

Basic Skill	P.G. Degree	Degree	Diploma
Core Engineering			
Design	0.78	0.70	0.46
Production	0.69	0.69	0.64
Maintenance	0.60	0.64	0.63
Quality Control	0.70	0.68	0.57
Materials Management	0.64	0.63	0.51
Research & Development	0.75	0.66	0.50
Project Planning & Execution	0.73	0.63	0.54
Use of Computer	0.77	0.88	0.56
New Technology			
Design	0.80	0.71	0.46
Production	0.70	0.77	0.63
Maintenance	0.66	0.71	0.63
Quality Control	0.78	0.75	0.54
Materials Management	0.66	0.69	0.60
Research & Development	0.79	0.69	0.56
Project Planning & Execution	0.64	0.67	0.62
Use of Computer	0.82	0.79	0.66

46. As can be seen from the above Table, the relevance of skills possessed by post graduate degree holders in the core disciplines is better than 'good' and close to 'very good' for design, use of computer, R&D, and project planning work. The perception of the employers regarding the skills possessed by the degree holders by and large has also been good. However, in the case of diploma holders, the situation is far from satisfactory as for most basic skills the grade indices are less than 0.60.

47. Yet another indicator of the relevance of courses to the users is the employers' assessment of dispersions of actual vis-à-vis expected performance of graduates of various programs in engineering. Dispersion is the degree of satisfaction of employers with the performance of employees. Table 1.16 indicates the employers' perceptions of their employees in terms of wide, medium or narrow dispersion. In the case of new technologies, over 50 per cent of the employers opined that there was narrow dispersion

in their engineers' performance. However, in respect of technicians the dispersion was quite significant. In the core disciplines, most employers felt that there was medium to wide dispersion between actual and expected performance of both engineers and technicians. This clearly indicates that *education and training in core disciplines has not kept pace with the current needs of the employers.*

Table 1.16: Percentage Distribution of Employers by Range of Dispersion between Actual and Expected Performance of Their Employees

Employee Category	Dispersion Range		
	Wide	Medium	Narrow
Engineers			
Core Disciplines	16	73	11
New Technologies	26	21	53
Technicians			
Core Disciplines	4	37	23
New Technologies	18	45	36

48. *Emerging areas and new courses in engineering and technology*: Information elicited during the IAMR study from the employers suggests that Digital Electronics & Communication, Computer Networks, Electronic Commerce, Broad Band Integrated Digital Networks, and Concepts of Operating Systems Development are the new areas likely to be of great interest and concern in the future in the area of Information Technology In the Bio-Technology area, Plant Vaccine, Transgenic Plant Cell Biology and Biological Engineering are the areas identified. Advanced Materials Science, Advanced Tool Engineering, Computer Integrated Manufacturing, Digital & Micro-Electronics, Mechatronics, Plant & Equipment Maintenance and Product Engineering are the emerging areas identified in the areas of Manufacturing and Processing. Total Quality Management in the area of Mechanical Engineering; and Computerized Instrumentation, Fluid Power Engineering and High Voltage DC in the area of Power Systems have been identified as the emerging areas needing attention. It is also anticipated that more and more Computer Aided Design and Computers will be used in Civil Engineering and Architecture. While many employers feel that the existing courses available at different levels can be updated by suitable modification of the curricula by introducing new elements, some employers were very specific with regard to starting of new courses. However, *starting of a new course should be based on the economic viability of running the course,* as the cost of good professional education is high all over the world.

49. In **summary**, the vast infrastructure for higher technical and scientific education created and supported largely with public funds in India has so far served the country well. However, it is now facing major problems of governance and financing. Most of the colleges are far below international standards and are unable to keep pace with the developments in science and technology. There is lack of ownership and innovations leading to poor quality output and wastage of resources. The system can not meet the current and future needs of the country without some major reforms at all levels, with significant private and public inputs.

ANNEX 2

POLICY SUPPORT FOR SCIENTIFIC AND TECHNICAL MANPOWER DEVELOPMENT IN INDIA

A. Responsibilities and Policies of Government of India

1. India has formally recognized the importance of higher education, and science and technology for national development and committed itself to development of scientific and technical manpower. The Constitution of India (Seventh Schedule) places the responsibility on Government of India for co-ordination and determination of standards in institutions for higher education or research and scientific and technical institutions. Government of India is also responsible for Central Universities and for institutions for scientific or technical education financed wholly or in part and declared by Parliament by law to be institutions of national importance. The Constitutional Amendment of 1976 places education, including technical education in the concurrent list of the Government of India and the states.

2. The Government of India established, through Acts of Parliament, the University Grants Commission (UGC) in 1956 and the All India Council for Technical Education (AICTE) in 1987 for promotion, co-ordination, and determination & maintenance of standards of higher education and technical education, respectively. During the last 50 years, Government of India has also established and supported a number of high level institutions and Central Universities and provided aid to institutions/universities established or aided by the states. The support is provided through programs/schemes of the Department of Education, UGC or AICTE, for which the budget is approved by the Parliament. Research and training funding is also provided for specific programs by other Government Ministries and Departments (e.g., Ministry of Health, Ministry of Agriculture, and Departments of Science & Technology (DST), Electronics (DOE), Space (DOS), Biotechnology (DBT), Environment (DOEn), Scientific & Industrial Research (DSIR), Atomic Energy (DAE), etc.).

3. Over the years, the Parliament has adopted major policy resolutions related to higher education, and science and technology. The developments in S&T sector in India have largely been guided by its Scientific Policy Resolution (1958) (Ref. 2) with the following aims:

i) To foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects--pure, applied and educational;
ii) To ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation;
iii) To encourage, and initiate, with all possible speed, programs for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence;
iv) To ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity; and

v) To encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom.

4. The **National Policy of Education** (adopted in 1986 and modified in 1992) (Ref. 4), which improved upon the National Education Policy of 1968 (Ref. 3), has detailed sections on higher education and on technical education covering a range of operational, financial and technical issues. The Policy states:

- Education is a unique investment in the present and the future; education will be treated as a crucial area of investment for national development and survival;
- In higher education in general, and technical education in particular, steps will be taken to facilitate inter-regional mobility by providing equal access to every Indian of requisite merit, regardless of his origins;
- In the areas of research and development, and education in science and technology, special measures will be taken to establish network arrangements between different institutions in the country to pool their resources and participate in projects of national importance;
- In the context of the unprecedented explosion of knowledge, higher education has to become dynamic as never before, constantly entering uncharted areas;
- Autonomous colleges will be helped to develop in large numbers until the affiliating system is replaced by a freer and more creative association of universities with colleges; autonomy and freedom will be accompanied by accountability;
- Research in the universities will be provided enhanced support and steps will be taken to ensure its high quality;
- The reorganization of technical education and management education should take into account the anticipated scenario by the turn of the century, with specific reference to the likely changes in the economy, social environment, production and management processes, the rapid expansion of knowledge and great advances in science and technology;
- Institutions will be encouraged to generate resources using their capacities to provide services to the community and industry;
- Excellence in performance of institutions and individuals will be recognized and rewarded;
- Networking systems will have to be established between technical education and industry, R&D organizations, programs of rural and community development, and with other sectors of education with complementary characteristics;
- Resources, to the extent possible, will be raised by mobilizing donations, raising fees at higher levels of education, effecting savings by efficient use of facilities, levying a cess or charge on user agencies (including government departments) and entrepreneurs. The government and the community in general will find funds for equality of access, quality and functional effectiveness of educational programs, generating knowledge and developing technologies in scientific fields crucial to self-sustaining economic development.

5. The **Technology Policy Statement** (Ref. 5) states:

- Research and Development, together with science and technology education and training of a high order, will be accorded pride of place. Consolidation of the existing scientific base and selective strengthening of thrust areas in it are essential. Special attention will be given to the promotion and strengthening of the technology base in newly emerging and frontier areas such as information and materials sciences, electronics and bio-technology. Basic research and the building of centers of excellence will be encouraged.
- Skills and skilled workers will be accorded special recognition. The quality and efficiency of the technology generation and delivery systems will be continuously monitored and upgraded. All of this calls for substantial financial investments and also strengthening of the linkages between various sectors (educational institutions, R&D establishments, industry and governmental machinery).

6. A *draft paper* for a **New Technology Policy** (NPT), issued by the Department of Science and Technology in1993 (Ref. 25) states:

- In order to enable large sections of our society to derive the benefits from science and technology, this policy is directed to encourage industries for enhancing human skills to upgrade existing technologies to comparable international levels as well as to attain such levels for newer and emerging technologies.
- Deliberate steps would be initiated to continuously augment the number of scientific and technical personnel in relation to the country's population. A new balance of ratios between scientific and technical personnel will also be aimed at. Towards achieving this objective, attention will be directed to further enlarge the base of polytechnics, technical and vocational institutes, and engineering institutions and launch programs for training and retraining industrial and technical personnel in numbers significantly more than what has been attempted hitherto. Industries will be involved in this process of upgrading the human skills.
- Improvement of the quality of management of R&D institutions will receive special attention. Pursuit of R&D as a career prospect will be deliberately encouraged through further concrete measures so as to attract scientists and technologists to the challenges of creative science and innovative development with a target of doubling their number in R&D by 2000 AD. This will include innovative measures to attract and to utilize scientific and technological talents of Indians all over the world.
- Specific programs will be evolved to nurture and reward talented personnel contributing notably to technology development. Accomplishments by skilled technicians will be recognized and rewarded. The overall direction would be to create an atmosphere and opportunities to promote technological innovation and excellence.

- Specific emphasis will be laid on induction of professionals fully conversant with the latest technologies in Ministries/Departments, which heavily depend on crucial technology inputs.

On improving linkages, the draft NPT recommends:

- promoting university-industry linkages by diverse means, including adjunct positions for necessary personnel;
- developing consortium approach involving academic institutions, national laboratories, including those of the mission agencies namely, Department of Atomic Energy, Space, and Defence Research and Development Organisation, wherever feasible, and the user industry for goal oriented programs and new product development;
- facilitating easy mobility of personnel among universities, laboratories, industry (including R&D institutions connected with industry) and the Ministries.

Under Policy Implementation, the draft NPT states:

- R&D institutions including academic institutions would be encouraged to interact with industry and other agencies for contract projects. Income arising out of such initiatives will become additional resources for furthering their infrastructure and other R&D activities.

7. The **Information Technology Policy** of the Government of India also, includes many references to need and support of development of appropriate scientific and technical manpower at various levels to make India a leading country in information technology.

8. The policy statements, extracted above, act as guiding principles in developing plans and programs for government support for technical and scientific manpower development in India. These efforts form a part of Five-Year Plans of the Government.

B. Main Thrusts and Strategies in Higher Scientific and Technical Education in the Ninth Five Year Plan of Government of India (1997-2002) (Ref. 17)

9. The IX Plan treats education as the most crucial investment in human development. It identifies the following critical areas in Higher Education for action:

i) Relevance and quality
ii) Use of media & education technology
iii) Structure of curriculum
iv) Access and equity
v) Management of education
vi) Resource mobilization and utilization

10. For each of these areas, specific actions are identified. In summary, these include: (a) strong linkage with industry and improvement of employability of graduates; (b) orientation of post-graduate courses and research towards applied field; (c) faculty improvement; (d) faculty exchange between university and industrial houses; (e) multi-media approach to teaching; (f) structural changes in curricula to shift from rigid structured programs to credit-based system with choice of courses; (g) reduction of regional imbalance; (h) strengthening of distance education facilities; (i) changes in UGC legislation for better linkages with universities; (j) better fiscal discipline; (k) resource sharing between neighboring institutions; (l) resource mobilization through fee restructuring, public funding and industrial funding; (m) better accountability through leveraging UGC funding, evaluation, and model code of governance to minimize political interference and improve standards; and (n) extension education for community.

11. For Technical Education, the IX Plan lays emphasis on (Ref. 17):

i) Quality improvement
ii) Infrastructure Development and Innovations
iii) Flexibility, mobility and curricula
iv) Governance of institutions
v) Excellence in polytechnic education

The action plan includes: (a) greater autonomy and deemed university status to institutions; (b) resource mobilization; (c) better utilization of existing capacity; (d) flexibility in course structure and upward mobility through modular courses; (e) faculty development; (f) greater linkage with industrial establishments; and (g) community services.

12. Science and Technology is a subject of extensive coverage in the IX Plan. On S&T manpower development, it states (Ref. 17):

- Scientists with exceptional capabilities should be nurtured and supported fully by offering them, within the country facilities comparable with international standards.
- There is need to create conducive environment in educational institutions for developing creative skills and innovative capabilities with greater emphasis on modern management techniques, technology marketing and IPR (intellectual property rights) related issues.
- Intensive efforts should be made to generate maximum resources for R&D from the production and service sectors.
- Joint R&D ventures between Indian institutions and those abroad should multiply in mutually beneficial technology areas.
- Attracting creative scientific talent to the frontier areas of research and basic sciences should continue.
- The academic community should gradually motivate the faculty to do research by giving them a sense of empowerment and autonomy of functioning within the university system.

- The inter-university centers, which are providing very valuable services to the university research community, should be encouraged by earmarked support through the UGC.
- The operation of research funds both at the level of the individual research worker and at the institutional level needs to be reviewed so that sub-critical support is avoided.
- The extra-mural research funding should be enhanced by carefully building up a rigorous, objective, constructive and credible peer review system.
- Efforts would also be made to provide financial support to the universities and related institutions for improving S&T infrastructure.
- Some regional science and engineering research libraries should be established in chosen institutions with networking facilities.
- There is need for introduction of some high quality under graduate science programs at selected institutions.
- In order to improve the technological competitiveness in the global market and enhance the technology export potential, attention has to be focussed on areas such as university-corporate R&D spending, lab to industry conversion, indigenous innovation, IPR protection, etc.

13. In addition to planning through the Five Year Plans, long term vision for India in various sectors is also developed by expert groups and professional bodies from time to time to help the central and state governments, institute management bodies, and industries to plan their activities and to take advance action. Recommendations of one such major study is presented next because of its possible impact on technical and scientific manpower development in India.

C. A Vision for the New Millennium: India 2020

14. Technology Information Forecasting and Assessment Council (TIFAC), a registered society under the Department of Science and Technology of the Government of India, had conducted a major national exercise with the involvement of experts from academic institutions, R&D laboratories, Government, Industry and users to determine trajectories for long term vision for India. This exercise conducted during 1994-95 resulted in 25 detailed reports called *"Technology Vision for India 2020"*. These cover sixteen key sectors such as agriculture, agro-food processing, chemical industries, life sciences, engineering industries, electronics, and strategic industries. The documents were released to the nation by the Prime Minister of India on August 2, 1996. A brief overview of the vision envisaged in those documents is given in a book entitled, *'India 2020: A Vision for the New Millennium'* (Ref. 18). In the summary of *recommendations* it states:

- India should become a developed nation by 2020 and one of the five biggest economic powers.
- To achieve this goal, several steps are to be taken in agriculture such as making Eastern India a wheat granary and increasing the use of hybrid rice, as also for improving the quality and yield of various crops, vegetables and other products. Environmental considerations in agriculture gain attention.

- India should capitalize on the agricultural core strengths to establish a major value-adding agro-food industry based on cereals, milk, fruits, and vegetables to generate domestic wealth. Also, make India a major exporter of value-added agro-food products. Agro-food industry and distribution systems should absorb a number of persons rendered surplus from increasingly productive and efficient agriculture.
- A number of engineering industries and service businesses should grow around the agro-food sector.
- India should capitalize on its vast mineral wealth to emerge as a major techno-industrial global power in various advanced and commercial materials: steel, titanium, aluminum, rare earth materials, etc.
- Indian chemical industry should be transformed into a global technological innovator in clean processes and specialty chemicals, and new drugs and pharmaceuticals; a major business should be created in natural products. Vast bio-diversity should be transformed into wealth of people and the nation through selective technological interventions; Indian marine resources are to be transformed into economic strength.
- There is to be a resurgence of Indian engineering industry: machine tools, textiles, foundry, electrical machinery, and transport equipment. India is to become a net exporter of technology by 2010 in these areas and an important world leader in embodied software for manufacturing and design; also a key contributor to the field of flexible manufacturing and intelligent manufacturing.
- India should emerge as a global leader in the services sector with its vast and skilled human resource base being its core strength. The services will range from the simple to the most sophisticated ones using the emerging digital and communication revolution. The services sector is not to be a money-spinner but will also employ a good proportion of our people, often in self-employment, with abilities ranging from simple skills to super skills.
- While India needs to pay most attention to economic areas and employment generation, both crucial to making her a developed country, attention should also be paid to the strategic sectors. It is necessary to draw Indian industry, especially the private sector, into these high-tech areas not merely for fabrication but for design, development, production, marketing and post-sale services. India should also emerge as a major exporter of products and services resulting from its capabilities in high-tech areas.
- The health of people is vital even while pursuing the all-round rapid growth of the economy and technological prowess. India should attend to short-term rapid action and emerge as a nation with excellent health service cover.
- In order to achieve the vision, several crucial actions need to be taken to ensure speedier growth of infrastructure: energy, quality electric power in particular, roads, waterways, airways, telecommunication, ports, etc. Several short-term measures and some unconventional steps need to be taken. The long-term action should be aimed at providing world-class facilities for all parts of India. Rural connectivity is crucial even in the short run if the boom in agriculture and agro-food sector is to be utilized fully. In addition, the progress in information technologies is leading to the possibility of very advanced world-class industries and businesses being established in villages.

The above overview provides a broad perspective for scientific and technological activities and the types of knowledge base and skills required in the coming years.

D. Future Strategies for Scientific and Technical Manpower Development

15. The current status and future of higher education, and science and technology in India has been a subject of many discussions, seminars and publications. As a part of the present study, a ***National Seminar on Scientific and Technical Manpower Development in India – Status, Need and Future Strategies*** was organized with support from the Government of India and the World Bank on April 2-3, 1998 by the Indian Institute of Technology, Delhi. The presentations included papers from industry, government departments/bodies, professional bodies, academic institutions, and invited experts (list of speakers is given at the end of this report). Based on the presentations and discussions that followed, the following recommendations were made. Specific action items were also suggested and these are summarized in the seminar proceedings (Ref. 6):

- *Faculty:* The role of faculty in manpower development is most critical. There is a need to create an appropriate environment, through policy support and through a framework of incentives, to get the best people into the teaching profession. Outstanding people will be attracted to the teaching profession if they are given respect, facilities, freedom and emoluments/perks commensurate with the position they deserve in the society. Also, procedure for obtaining patents and exploiting intellectual property rights must be simplified so that there is an encouragement for scientists and technologists.
- *Resource Generation:* The cost of training scientific and technical personnel is very high. The increasing demand for scientific and technical manpower and limited availability of funding from the Government calls for generation of additional resources. Deficit financing of the institutions by the Government is a de-motivator for resource generation. Funding patterns, which provide incentives for internal resource generation, should be instituted.
- *Efficient Utilization of Existing Infrastructure and Facilities:* At the present, majority of laboratories and workshops are not used for more than a few hours a day. Measures are needed to optimally utilize the infrastructure and facilities. Opening of new technical or scientific institutions should be done only in the absence of other alternatives. In general, it may be more economical to strengthen the infrastructure and facilities of the existing institutes, universities and colleges and increase the student intake.
- *Role of Industry:* To reduce the mismatch between the requirements of the industry and the technical skills acquired by the students, there is an urgent need for close cooperation between the academic institutions and the industry.
- *Declining Enrolment of Students for Science Education:* Science graduates provide the foundation for manpower needed for research and breakthroughs – the backbone for national development. However, talented and creative young minds are no longer interested in pursuing higher education in science stream. Urgent steps are needed to reverse these trends.

- *Role of Information Technology (IT) in Future Manpower Development:* IT will have an increasing impact on all facets of economy. It offers enormous opportunities for delivery of academic programs and must be fully exploited. This can also be used for better networking between industry, academia and R&D laboratories.
- *Role of Professional Societies:* The professional societies are presently involved in providing education to aspirant candidates in the non-formal sector. In the present day changing scenario, the professional societies' role has to be enlarged and made more focussed and practical. Accreditation of technical and scientific institutions is important for maintaining standards and bringing in collaboration with industry.
- *Governance:* Most of the institutions in the country suffer from bureaucratic bottlenecks and outdated rules and regulations. The single most important step needed in the changed global scenario (to remain competitive) is to get out of the rigidity of the existing system. The academic system must, therefore, adopt a style of governance, which enables and sustains flexibility with accountability.

E. Recommendations from International Conferences/Experience Relevant to Indian Higher Education

16. With a view to gain from international experience of other countries, India has generally sent high-level delegations to major international conferences. The Minister of Human Resource Development led the Indian delegation at the ***World Conference on Higher Education***, held in Paris during October 5-9, 1998. The Conference adopted a *"Declaration on Higher Education for the Twenty-first Century: Vision and Action"* and the *"Framework for Priority Action for Change and Development of Higher Education"* (Ref. 19). The Framework identifies (i) priority actions at national level, (ii) priority actions at the level of systems and institutions, and (iii) actions to be taken at international level, and in particular, to be initiated by the UNESCO. Important statements and recommendations, which have direct relevance to the Indian Higher Education system in science and technology, are extracted here for ready reference.

17. The *Declaration on Higher Education for the Twenty-first Century: Vision and Action* states:

- "Everywhere higher education is faced with great challenges and difficulties related to financing, equity of conditions at access into and during the course of studies, improved staff development, skills-based training, enhancement and preservation of quality in teaching, research and services, relevance of programs, employability of graduates, establishment of efficient co-operation agreements and equitable access to the benefits of international co-operation. At the same time, higher education is being challenged by new opportunities relating to technologies that are improving the ways in which knowledge can be produced, managed, disseminated, accessed and controlled". (Preamble)

- " ... a substantial change and development of higher education, the enhancement of its quality and relevance, and the solution to the major challenges it faces, require the strong involvement not only of governments and of higher education institutions, but also of all stakeholders, including students and their families, teachers, business and industry, the public and private sectors of the economy, parliaments, the media, the community, professional associations and society as well as a greater responsibility of higher education institutions towards society and accountability in the use of public and private, national or international resources," (Preamble)

- " ... higher education systems should enhance students' capacity to live with uncertainty, to change and bring about change, and to address social needs and to promote solidarity and equity; should preserve and exercise scientific rigor and originality, in a spirit of impartiality, as a basic prerequisite for attaining and sustaining an indispensable level of quality; and should place students at the center of their concerns, **within a lifelong perspective,** so as to allow their full integration into the global knowledge society of the coming century," (Preamble)

- "Higher education institutions and their personnel and students should enjoy full academic autonomy and freedom, conceived as a set of rights and duties, while being fully responsible and accountable to society". (Article 2e)

- "...the rapid and wide reaching demand for higher education requires, where appropriate, all policies concerning access to higher education to give priority in the future to the approach based on the merit of the individual...". (Article 3c)

- "The advancement of knowledge through research is an essential function of all systems of higher education which should promote post graduate studies. Innovation, interdisciplinary and Trans-disciplinary, should be promoted and reinforced in programs with long-term orientation on social and cultural aims and needs. An appropriate balance should be established between basic and target oriented research". (Article 5a)

- "Relevance in higher education should be assessed in terms of the fit between what society expects of institutions and what they do....". (Article 6a)

- "Higher Education should enhance its contribution to the development of the whole education system, notably through improved teacher education, curriculum development and educational research". (Article 6c)

- "As a life source of professional training, updating and recycling, institutions of higher education should systematically take into account trends in the world of work and in the scientific, technological and economic sectors. In order to respond to the work requirements, higher education system and the world of work should jointly develop and assess learning processes, bridging programs, and prior learning assessment and recognition programs, which integrate theory and training on the job. Within the framework of their anticipatory function, higher education institutions could contribute to the creation of new jobs, although this is not their only function". (Article 7c)

- "Developing entrepreneurial skills and initiative should become major concern of higher education, in order to facilitate employability of graduates who will increasingly be called upon to be not only job seekers but also and above all to become job creators.....". (Article 7d)

- "To achieve these goals, it may be necessary to recast curricula, using new and appropriate methods, so as to go beyond cognitive mastery of disciplines. New pedagogical and didactical approaches should be accessible and promoted in order to facilitate the acquisition of skills, competence and abilities for communication, creative and critical analysis, independent thinking and team work in multicultural contexts, where creativity also involves combining traditional or local knowledge and know how with advanced science and technology," (Article 9c)

- "National and institutional decision-makers should place students and their needs at the center of their concerns, and should consider them as major partners and responsible shareholders in the renewal of higher education". (Article 10c)

- "To attain and sustain national, regional or international quality, certain components are particularly relevant, notably careful selection of staff and continuous staff development, in particular through the promotion of appropriate programs for academic staff development, including teaching/learning methodology and mobility between countries, between higher education institutions, and between higher education institutions and the world of work as well as student mobility within and between countries". (Article 11c)

- "Higher education institutions must be given autonomy to manage their internal affairs, but with this autonomy must come clear and transparent accountability to the government, parliament, students and the wider society". (Article 13b)

- "The diversification of funding sources reflects the support that society provides to higher education and must be further strengthened to ensure the development of higher education, increase its efficiency and maintain its quality and relevance. Public support for higher education and research remains essential to ensure a balanced achievement of educational and social missions". (Article 14a)

18. The *Framework for Priority Action for Change and Development of Higher Education* states:

i) States, including their government, parliament and other decision makers, should:
   - develop higher education institutions to include life long learning approaches, giving learners an optional range of choice and a flexibility of entry and exit points within the system, and redefine their role accordingly, which implies the development of open and continuous access to higher learning and the need for bridging programs and prior learning assessment and recognition;

- make efforts, when necessary, to establish close links between higher education and research institutions, taking into account the fact that education and research are two closely related elements in the establishment of knowledge;
- develop initiative schemes of collaboration between institutions of higher education and different sectors of society to ensure that higher education and research programs effectively contribute to local, regional and national development (Action I.1d, e, f);

ii) Concrete steps should be taken to reduce the widening gap between industrially developed and developing countries, in particular the least developed countries, with regard to higher education and research (Action I.4);

iii) Each higher education institution should define its mission according to the present and future needs of society (Action II. 5);

iv) In establishing priorities in their programs and structures, higher education institutions should:

- take into account the need to abide by the rules of ethics and scientific and intellectual rigor, and the multi-disciplinary and Trans-disciplinary approach;
- be primarily concerned to establish systems of access for the benefit of all persons who have the necessary abilities and motivation;
- use their autonomy and high academic standards to contribute to the sustainable development of society and to the resolution of issues facing the society of the future;
- set their relations with the world of work on a new basis involving effective partnerships with all social actors concerned .....all this within a framework of responsible autonomy and academic freedoms;
- ensure high quality of international standing, consider accountability and both internal and external evaluation, with due respect for autonomy and academic freedom, as being normal and inherent in their functioning and institutionalize transparent systems, structures and mechanisms specific thereto;
- as life-long education requires academic staff to update and improve their teaching skills and learning methods.......establish appropriate academic staff development structures and/or mechanisms and programs; and
- promote and develop research which is a necessary feature of all higher education systems, in all disciplines (Action II. 6a, b, c, f, g, h, i);

v) The use of new technologies should be generalized to the greatest extent possible to help higher education institutions to reinforce academic development, to widen access, to attain universal scope and to extend knowledge, as well as to facilitate education throughout life. Governments, educational institutions and the private sector should ensure that informatics and communication network infrastructure, computer facilities and human resources training are adequately provided (Action II.8).

19. Being a signatory to the Declaration and the Priority Action document, India is committed to these recommendations for policy support.

ANNEX 3

Table 3.1: Higher Educational Reforms
Changes and/or Useful Operational Models—Successes or Weaknesses in OECD

Country	USA	Japan	United Kingdom	Australia	Korea	Netherlands	Other European
Proportion of 18-21 years olds enrolled in university level education	21.9%	N/A	20.9%	21.1%	21.5%	23.2%	Denmark - 7.9% Spain - 24.9% Germany - 7.9%
Higher education expenditure as a % of total government spending	3.3%	1.5%	2.7%	3.9%	1.4% Note that the university system is dominated by private universities (enrolling about 75% of students) so government expenditure is only a small proportion of national expenditure	2.9%	Denmark - 3.3% France - 1.8% Germany - 2.1%
Extent of autonomy in higher education institutions	This varies between states and public and private institutions. All institutions must meet Federal and state regulations (e.g., equal opportunities policies). Public institutions have less autonomy since they are governed by state appointed or elected governing bodies and are more dependent on state funding. Private institutions are, in principle, free from direct state control but their autonomy is restricted by their dependence on state and Federal funds *Issues: Private institutions have begun to question the impact of state and Federal funding on their autonomy.*	There are three categories of institutions with different levels of autonomy. National public universities are not legally separate from central government; other public universities belong to either prefectures or municipalities. These face budgetary as well as administrative controls from government (e.g., approval required for the appointment of presidents). Private institutions are legally independent but are subject to institutional and curriculum standards (e.g., physical space, program content) if they receive government subsidies.	HEIs are independent private bodies. However, they are largely government funded and so accountable to government for the use of public money	As in the UK	All private institutions must receive a license to be a university for which there are criteria. These are related to inputs rather than process. Most of the public universities are "national" in that they are owned and funded by central government (mainly MoEd but one or two fall under the Ministry of Science & Technology). There are also a few provincial universities. All staff in public universities are civil servants on set pay scales. Government sets student quotas and staff numbers, appraises any new courses and provides virtually all the funding. Institutional autonomy is very limited although there is an intention to change this	There are two types of higher education institutions: higher professional education colleges (HBOs) of which some 70% are private and universities of which 3 out of 13 are private. Both private and public institutions are funded by the State and accountable for the use of public funds. They have a tradition of academic freedom and autonomy and assume responsibility for the content of their degree programs. Block funding was introduced in 1993 based on criteria for the number of students and performance (e.g., retention rates and outcomes of performance reviews)	The trend across Europe has been towards greater institutional autonomy (e.g., France, Germany, Spain) although to a lesser extent than in the UK and the Netherlands.

Country	USA	Japan	United Kingdom	Australia	Korea	Netherlands	Other European
Mechanisms used for expanding HE	Growth in state funding, private philanthropic support and increases in tuition fees. While some states have reduced expenditure (e.g., California), overall state funding has increased by 8.5% since 1996. The development of distance learning programs has also increased the scope for future expansion at lower cost	Post-war expansion has relied heavily upon private provision and financing facilitated by a policy framework which permits private (non-profit) entry into the market. The number of students in private institutions has grown by 40% over the last decade amounting to 70% of total student enrolments. Both public and private institutions rely increasingly on tuition fees; these have grown by ten times over the last 20 years in public institutions.	Reductions in unit costs have allowed for significant expansion in recent years. Current targeted growth is being achieved through the introduction of student tuition fees and small real increases in funding	The Higher Education Contribution Scheme was introduced in the 1980s whereby students contribute to the cost of their studies during their working life provided their income reaches the national average	Government policy has consistently been that the expansion of the system should be almost exclusively within the private sector - hence the dominance of private institutions. There are thus many small, fairly new institutions offering courses mainly in those subjects which are cheap to provide. Students at both public and private institutions pay fees although public university fees are less than half of those in private universities where fees are set at full cost	After a period of significant expansion in the 1970s and 1980s, the HE sector continues to grow although more slowly. This has been allowed by a reduction in per student expenditure (unit costs), increases in tuition fees and a reduction in the number of years in which students are eligible for financial assistance. This limit is still comparatively high at 6 years for full-time and 9 years for part-time courses.	The introduction of government student loan schemes has facilitated growth in many countries. The Scandinavian countries are leaders in this area having had loans as a key component of their student support systems since the mid 1980s
Quality assurance mechanisms (including approaches to accreditation)	There are no nationwide mechanisms in place. Private regional accrediting bodies are the principal evaluators of academic quality; most professions (e.g., law) also have their own accrediting bodies. Many institutions also undertake periodic peer reviews made up of visiting faculty from comparable institutions. Competition for research funding at the Federal and state levels promotes quality in research. States are increasingly using output measures in funding to reward quality and effectiveness	New programs and institutions are subject to approval from the Ministry. There are no formal systems of accreditation or performance review for established programs or organizations. The University Council has initiated a number of reforms since the early 1990s including the promotion of self-evaluation; 60% of universities now publish their results.	All HEIs are subject to assessment of research and teaching quality once every 4-5 years. Research funding is closely tied to the outcomes of the research assessments; a proportion of funding for teaching will be allocated on the basis of quality audits in the future. The sector is also considering the establishment of a professional body to safeguard standards in university teaching	Research programs are evaluated by the funding bodies (e.g., Australian Research Council) often with reference to overseas academics to ensure that Australian institutions keep in line with good international standards. Professional bodies are also becoming increasingly involved in the approval of degree programs. The Higher Education Council has introduced a number of initiatives to promote quality since 1992 including a fund of A$75m to reward institutions for effective practice in quality assurance. In 1996, the government announced a new approach to quality with the introduction of a nationwide quality assessment process and the establishment of a new agency.	Very similar to Japan but without the reforms. There is discussion about some more regular and rigorous accreditation system.	All HEIs are subject to a review of teaching and research every 6-7 years by visiting committees. The Inspectorate of Education reviews the assessments and the institutional response. The Ministry may decide to close a department which has been judged to be performing badly. There is no formal accreditation system for courses in universities; HBOs have begun to experiment with the accreditation of professional programs by professional bodies.	

Country	USA	Japan	United Kingdom	Australia	Korea	Netherlands	Other European
Setting and funding of national priorities for research	Federal agencies, which fund research (e.g., National Science Foundation), set general priorities. Funds are generally allocated on the basis of peer review of individual faculty members' applications. Corporations also fund research and contract with institutions for particular research projects *Issues: University research partnerships with corporations have led to questions about the traditional role of universities in basic research and the free publication of research results.*	There are multiple sources of research funding including Mombusho, the Agency for Science and Technology and the Ministry for International Trade and Industry. Funding is not specifically allocated on the basis of research performance. *Issues: The institutional arrangements for competitive and performance-orientated research are weak*	HEIs are graded according to the quality and volume of research undertaken - evaluated in research assessment exercises held every 5 years. This ranking determines the allocation of baseline research funds. Other research funding is bid for on a competitive basis. *Issues: Concern that, to date, the funding system which rewards excellence in research, has accentuated a bias towards research (as opposed to teaching) within institutions*	The Australian Research Council provides policy advice to national Government and makes recommendations on the distribution of research funds. A competitive bidding system is in place for Research Council funds.	The government has a clear policy for research in the science, technology and engineering areas, as it believes that this will provide the engine for economic growth in the early part of next century. Funding is primarily by means of competitive peer-reviewed bidding but government does not cover the full costs of the research. This puts the less well-funded institutions at a disadvantage. The government is currently carrying out a university-rating project and there is an intention to focus the research effort on a few institutions in the future.	Government research funding is allocated on the basis of an ex post assessment of research quality. In addition, institutions can bid for individual grants from the national research councils. *Issues: Concern that the research funding mechanism may place too much emphasis on the volume as opposed to the quality of publication*	

Source: OECD 1998, Education at a Glance. Table c5.2b.
OECD 1998; Education at a Glance. Table B2.1

Table 3.2: Transition Economies - Educational Reforms Over 1993-98 Changes and/or Useful Operational Models—Successes or Weaknesses

(Abbreviations and acronyms used in this matrix are found at the end of the document)

Higher Education	Russia	Hungary	Romania	Poland	Czech Republic
Size (participation rates) of H. Ed. and proportion of government spending it attracts	There are 566 state institutions and 244 non-state institutions; about 20-25% high school graduates go to H.Ed institutions; in 1996, total education budget represents 3.7% of GDP, of which 17.8% is of federal education budget and 82.2% on regional budgets; H. Ed. spending takes 25.6% of federal education budget	25% of age cohort is in H. Ed.; Of government current education expenditure: H.Ed takes 17.8% expenditure, while primary takes 54.1%, and secondary takes 23.0%; H. Ed spending in 1996 is 0.9% of GDP (1.2% in 1991), while total education spending is 6.0-7.0% of GDP	14% of age group (18-22 yr.) (95/96); Of government current education expenditure: H. Ed takes 15.9% expenditure, while primary takes 44.9%, and secondary takes 23.8%; total education spending is 3.5-4.0% of GDP, while H. Ed. budget is 0.5-0.6% of GDP	Of government current education expenditure: H. Ed takes 16% expenditure, while primary takes 49.7% , and 20.5% is for secondary; Total education spending is 3.8% of GDP	Over 15% percent of 18 yr. of age enrolled; more that 40% of total applicants; Of government current education expenditure: H.Ed takes 14.7% expenditure, while primary takes 29.2% and secondary takes 53.5%
Mechanism used for expanding H. Ed.	None - there has been a slight decline in overall enrollment in the past few years (1995/6), even though the enrollment was relatively at very low level	Mainly through integration and growth of technical Ed. (i.e. TVU); some new institutions recently established by private business and churches (which amounts to about 10% of H. Ed institutions)	Massification, increased private education; funds increasing from both public and private	Since 92' MoE introduced a funding algorithm based on number of students aiming at encouraging expansion, but results are mixed; up to 96', the small sizes of institutions have not stimulated any integration	Establishing new universities and transforming some technical schools into post-secondary professional colleges
Quality assurance mechanism for H. Ed. (including accreditation and other government approaches)	Government controlled; but has no tradition of widescale application of assessment instruments based on research and international experience; in 1994/5 there had been a check-up process called "attestation" for accrediting new and reaccrediting existing institutions	The system is changing from being elitist to being more democratic; but now still under central control that seeks to ensure quality; there is no formal accreditation system; the H. Ed and Scientific Council is now (98') preparing to play important role in assessment and evaluation	A national level "Council of Academic Evaluation and Accreditation" supervises	Government controlled; there is no assessment system and no monitoring of courses offered; central regulations are the only guide the institutions have, which by no means guarantee standards or quality ***issue**: the lack of an evaluation system becomes extremely problematic when new types of courses are established*	The Council of H. Ed Institutions, consisting of academic senate from individual university, serves as a consultative to MoE. The Accreditation Commission advises on establishment of new H. Ed institutions
Degree of university autonomy	Changes started in 1986, strengthened by the passing of Law on H. Ed. and Postgraduate Education (1996), which further delegates authority and responsibility to individual institutions regarding curriculum development, teaching methods and internal management	The autonomy of H. Ed. has been widely accepted and assured by legal means, and norm-budgeting is now gradually substituted by a mixed budgeting process which grants part of the budget (research and maintenance funds) on a competitive basis; now (98') 85% budget from state, 7 from sale of service, 8% from others (i.e. rental of real estate)	High degree of autonomy, especially in the private sector Law of 1995 gives colleges considerable autonomy. But now the colleges have to develop their own managerial skills and capacity	Relatively high	Relatively high The 1990 Act restored autonomy of H. Ed institutions. Each university has an elected Academic Senate making basic decisions on activities of its own institution, such as budgeting, personnel, research and teaching programs
Setting and funding of national priorities for research	R&D expenditure accounts 0.7% of GNP; managed by Ministry of Science	yes - centralized; R&D expenditure accounts 0.8% of GNP	yes - centralized; funds come from the State and are allocated through 3 national level agencies: Ministry of Research and Technology; Academy of Science; University Research Council; R&D expenditure accounts 0.7% of GNP	R&D expenditure accounts 0.7% of GNP	R&D expenditure accounts 1.2% of GNP; Grants for Educational Research are awarded by MoE (such as: school research and school development fund, H. Ed. development fund) and by the Government Research Grant Agency

MGPE: Russia's Ministry of General and Professional Education; **MCE**: Hungary's Ministry of Culture and Education; **MoNE**: Romania's Ministry of National Education; **MoE**: Ministry of Education, **ML**: Ministry of Labor; **NRC**: Hungary's National Reconciliation Council.

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