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CHAPTER ON SINGAPORE FOR GOOD PRACTICES GUIDE ON THE POPULARISATION OF SCIENTIFIC AND TECHNOLOGICAL CULTURE IN THE COMMONWEALTH

In this chapter, we report on the efforts by Singapore to popularise scientific and technological culture. Firstly, we produce excerpts from policy speeches by Singapore leaders which outline Singapore's plans for the development of a scientific and technological culture. Next, we describe the work of the Ministry of Education, with the focus on its efforts in promoting science and technology.

Following this, we describe the work of the National Computer Board. This is followed by a description of the efforts of the Ministry of Education in promoting science and technology education. The third section deals with the work of the National Science and Technology Board and the Singapore Science Centre. The fourth section focuses on the efforts of the two universities in Singapore, viz. The National University of Singapore and the Nanyang Technological University. The final section deals with the work of the National Institute of Education.

Singapore’s Plans and Policies

Singapore’s plans for the development of a scientific and technological culture were also mentioned by Prime Minister Mr. Goh Chok Tong during his speech at the opening of the 7th International Conference on Thinking (June 2, 1997).

Excerpts from his speech are:

**Future Wealth Will Depend on Capacity for Learning**

A nation’s wealth in the 21st Century will depend on the capacity of its people to learn. Their imagination, their ability to seek out new technologies and ideas, and to apply them in everything they do will be the key source of economic growth. Their collective capacity to learn will determine the well-being of a nation.

We know three things about the future. First, it will be an intensely global future, with diminishing barriers to the flow of goods, services and information. Competition between cities, countries, sub-regions and regions will be intense. No country or region will have permanent advantages. There is no guarantee that it will always retain its competitive edge.

Second, knowledge and innovation will be absolutely critical. The recent victory of the computer Deep Blue over chess champion Gary Kasparov was not a triumph of machine over man but the triumph of human innovation, of organised human mastery of technology. Companies and nations which organise themselves to generate, share and apply new technologies and ideas more quickly than others will, like the early bird, catch the worm.

The third defining feature of the future is that it will be one of change, and increasingly rapid change. It will be change as a permanent state, not change as a transition to some known, final state. Change will be unpredictable but it will affect everything we do at work, in society and at home.

Singaporeans have to prepare for a bracing future - a future of intense competition and shifting competitive advantages, a future where technologies and concepts are replaced at an increasing pace, and a future of changing values.

Education and training are central to how nations will fare in this future. Strong nations and strong communities will distinguish themselves from the rest by how well their people learn and adapt to change. Learning will not end in the school or even in the university. Much of the knowledge learnt by the young will be obsolete some years after they complete their formal education. In some professions, like Information Technology, obsolescence occurs even faster. The task of education must therefore be to provide the young with the core knowledge and core skills, and the habits of learning,
that enable them to learn continuously throughout their lives. We have to equip them for a future that we cannot really predict.

Education: A Global Reassessment

Many countries around the world are recognising the critical difference that education will make. They are taking a fundamental relook at their education systems, assessing their strengths and weaknesses, and putting in place reforms to better prepare their people for the future.

The United States is a good example. The Americans are unsurpassed in their ability to produce highly creative, entrepreneurial individuals. Their best schools produce well-rounded, innovative students by putting them through a diverse and challenging curriculum. Their academic institutions and research laboratories are at the forefront of ideas and scientific breakthroughs, and infused with entrepreneurial spirit. And they have developed strong links between academia and industry, society and government. We in Singapore should learn from these strengths of the American system.

Employers and government in the US are, however, deeply concerned about the low average levels of literacy and numeracy among their young. President Clinton's Call to Action for American Education in the 21st Century attributes this to a watered-down curriculum and "a tyranny of low expectations" that many schools create among their students. His Call to Action issued four months ago, is a bold national plan. It will introduce national standards and national tests in reading and mathematics by 1999. It will also connect every classroom to the Internet by the year 2000 to help all students become technologically literate.

The new British Government has placed education as its first and most important priority. Like the Americans, they face the challenge of reversing a drift in standards that has occurred over many years. While the best British schools continue to nurture and develop rigorous and bold minds, standards nation-wide have declined. The new Government has set a target of having every child leave primary school with a reading age of at least 11, within the next decade. Barely half of them do today. The new strategy will recognise differences in ability among children in comprehensive schools and set them in different classes to maximise everyone's progress. They will focus on "levelling up, not levelling down".

The Japanese start from the other end of the spectrum. Their schools produce a higher average level of learning than in any other developed country. The capacity for learning that takes place in Japanese companies and Japanese society also exceeds that anywhere else. The story of post-war Japan is indeed one of extensive organisational innovation aimed at enhancing and sharing knowledge among all employees, especially on the factory floor. The organisational methods and motivations that the Japanese have developed are an achievement that we should study.

Yet the Japanese themselves believe there are serious limitations to their current educational system. Their mass-orientated school system, with its strict, centrally-controlled curriculum and heavy emphasis on testing students' knowledge of factual content was very successful when Japan was catching up with the West, and relied on knowledge and basic technologies developed in the West. Now that Japan has caught up with the West and in many areas leads the world, Japan's major employers believe its educational system will not produce the individual creativity, the originality of thought and inventiveness in basic knowledge that they need to retain their competitiveness. They worry about their ability to compete in the software and knowledge-driven industries of the future.

MITI's latest White Paper on the Japanese economy, released in May this year, drew attention to education as one of the main issues to be addressed if Japan is to regain its lead in productivity. It highlighted a need to revamp university education, including strengthening post-graduate education to develop more specialists.

Education for the Future: THINKING SCHOOLS, LEARNING NATION

Singapore has a strong education system, one that is widely recognised for having produced high levels of achievement among pupils of all abilities. As we prepare for the future, we will draw valuable lessons from how the US, Japan and other nations reform their educational systems to meet their needs. We will observe them closely to understand what works and what does not. But we must devise our own solutions, to preserve our own strengths and overcome our own limitations. We will learn and adapt from foreign experiments where useful, but we must chart our own future.
We cannot assume that what has worked well in the past will work for the future. The old formulae for success are unlikely to prepare our young for the new circumstances and new problems they will face. We do not even know what these problems will be, let alone be able to provide the answers and solutions to them. But we must ensure that our young can think for themselves, so that the next generation can find their own solutions to whatever new problems they may face.

Singapore's vision for meeting this challenge for the future is encapsulated in four words: THINKING SCHOOLS, LEARNING NATION. It is a vision for a total learning environment, including students, teachers, parents, workers, companies, community organisations, and government.

Towards THINKING SCHOOLS

The concept of THINKING SCHOOLS is central to this vision. Schools must develop future generations of thinking and committed citizens, capable of making good decisions to keep Singapore vibrant and successful in future.

The Ministry of Education is undertaking a fundamental review of its curriculum and assessment system to see how we can better develop the creative thinking skills and learning skills required for the future. It is studying how to cut back on the amount of content knowledge that students are required to learn, and to encourage teachers and students to spend more time on projects that can help develop these skills. We will use IT widely to develop communication skills and habits of independent learning. We will also strengthen National Education, through formal lessons as well as experiences outside the classroom, so as to develop stronger bonds between pupils and a desire to contribute to something larger than themselves.

Despite the proposed reduction and redefinition of the curriculum, the Ministry will ensure that students retain mastery over the core knowledge and concepts that give them the basis for further learning. We must also retain the high standards needed to stretch all our pupils and keep them striving for excellence. Whatever we do, we must not abandon these fundamentals as some others have done. We must not level down.

What is critical however is that we fire in students a passion for learning, instead of studying for the sake of getting good grades in their examinations. I must say this passion is generally lacking among our students, including many among our most able. Their knowledge will be fragile, no matter how many 'A's they get, unless they have the desire and aptitude to continue discovering new knowledge well after they leave school.

It is the capacity to learn that will define excellence in future, not simply what our young achieve in school. THINKING SCHOOLS must be the crucibles for questioning and searching, within and outside the classroom, to forge this passion for learning among our young.

THINKING SCHOOLS will also redefine the role of teachers. Every school must be a model learning organisation. Teachers and principals will constantly look out for new ideas and practices, and continuously refresh their own knowledge. Teaching will itself be a learning profession, like any other knowledge-based profession of the future. We will take this into account in reviewing our school curriculum. Teachers must be given time to reflect, learn and keep up-to-date. Then teachers will be able to make the textbooks and the Internet relevant to their students, relating what is learnt to current events and issues.

We will also give more autonomy to schools, so that teachers and principals can devise their own solutions to problems. THINKING SCHOOLS will be sites of learning for everyone, including those who shape our educational policies. Schools will provide lessons on how policies are working out on the ground, and give feedback on whether policies need to be changed. This process, of knowledge spiralling up and down the system, will be a defining feature of education for the future.

Towards a LEARNING NATION

We will make Singapore a LEARNING NATION, that goes beyond schools and educational institutions.

Learning goes beyond simply maximising an individual's potential. A nation's culture and its social environment will shape what learning means, and determine its impact. Everyone counts. What grandparents, parents, students and teachers, employees and managers, and leaders in society take to be true about learning will have a profound impact on whether we respond quickly and effectively as a
society to change. Our collective tolerance for change, and willingness to invest in learning as a continuous activity will determine how we cope with an uncertain future. We must make learning a national culture.

LEARNING NATION begins by recognising that education is a continuum, starting with the early pre-school years and continuing throughout life.

The research on brain development in the last decade indicates that the early years in a child’s life are critical for developing the foundations for future intellectual and social development. We have to study the implications of this research. We must develop ways to train parents to provide their children with rich experiences to help them develop during their initial pre-school years. We should help providers of pre-school education make quality pre-school learning widely available. We must develop an eagerness to learn and to interact in those early years.

LEARNING NATION will require innovation at every level of society. We must get every organisation to recognise that every individual, regardless of status, has a contribution to make to improving the organisation. Nearly all Japanese companies put learning and the development of human resources at the centre of their management philosophy. It is not a religious or political principle. It is an approach to human resources that has accounted for the extraordinary improvements in productivity they have achieved in the last few decades.

We must also get companies more involved in the education of our young as part of a total learning environment. Many of the leading American companies invest a significant amount of their professional employees’ time in ‘educational outreach’ activities - taking students from schools and giving them hands-on experiences and interesting them in real world technologies. We can follow their example.

We must set up comprehensive mechanisms to continually retrain our workforce, and encourage every individual to engage in learning as a matter of necessity. Even the most well-educated worker will stagnate if he does not keep upgrading his skills and knowledge. Every organisation must first recognise the importance of the matter. It must require that its employees go through regular learning as a routine part of working life. Every worker must be mobilised to think actively about how he can do better in his job.

We will bring about a mindset change among Singaporeans. We must get away from the idea that it is only the people at the top who should be thinking, and the job of everyone else is to do as told. Instead we want to bring about a spirit of innovation, of learning by doing, of everyone each at his own level all the time asking how he can do his job better. With such an approach of always looking out for improvement, always asking what is the purpose of our job and whether there is a better way to accomplish that purpose, we will achieve our ambition of national excellence. Excellence does not simply mean "outstanding": excellence means each of us at our own level, being the best that we can be.

We want to have an environment where workers and students are all the time thinking of how to improve. Such a national attitude is a must for Singapore to sustain its prosperity. THINKING SCHOOLS, LEARNING NATION is not a slogan for the Ministry of Education. It is a formula to enable Singapore to compete and stay ahead. It will provide a breakthrough in a critical area many developed countries themselves need to succeed in. And to the individual, it offers satisfaction in being able to exercise innovation, demonstrate initiative and enjoy the freedom to participate in improving his own life as well as his community and nation. All these add to the spiritual dimension of Singapore 21 - the best home for Singaporeans.

The world today is very different from the world 10 or 20 years ago. As change will occur at an even faster rate, we can expect the world in 10 or 20 years’ time to be radically different from the one we see today. Our capacity to learn, as individuals and as a nation, will decide our future, whether we stagnate, perish, or continue to succeed.
The Ministry of Education

Education Service Mission Statement.

This statement sets out the purpose of the Education Service, the philosophy of our education system, and the critical role that teachers play in shaping our future as a nation.

The national education system is one which must continually look forward and anticipate future needs so as to equip the young with the skills, knowledge and values to assure their livelihood and the country's survival and success. We must constantly review our policies, our curriculum and practices to ensure that we remain geared to the future.

Mission Statement

1. The wealth of a nation lies in its people - their commitment to country and community, their willingness to strive and persevere, their ability to think, achieve and excel. Our future depends on our continually renewing and regenerating our leadership and citizenry, building upon the experience of the past, learning from the circumstances of the present, and preparing for the challenges of the future. How we bring up our young at home and teach them in school will shape Singapore in the next generation.

2. The mission of the Education Service is to mould the future of the nation, by moulding the people who will determine the future of the nation. The Service will provide our children with a balanced and well-rounded education, develop them to their full potential, and nurture them into good citizens, conscious of their responsibilities to family, society and country.

3. People are Singapore's most precious resource. Every citizen is valuable and has a unique contribution to make. Through education every individual can realise his full potential, use his talents and abilities to benefit his community and nation, and lead a full and satisfying life.

4. Every child must be encouraged to progress through the education system as far as his ability allows. Advancement must always depend on performance and merit to ensure equal opportunity for all.

5. Every child should be taught at a pace he can cope with. Each should be stimulated to excel according to his individual aptitudes. The system must be flexible, to cope with pupils who mature mentally, physically, emotionally and socially at different rates.

6. Every child must learn to take pride in his work, to do his best and excel in whatever he does, and to value and respect honest work.

7. Education equips us with the skills and knowledge, as well as the right values and attitudes to assure the livelihood of the individual and the country's survival and success. We must learn to be self-reliant, yet able to work closely with others; individually competitive, yet with a strong social conscience. We must be flexible in mind and outlook to adapt constantly to a rapidly changing world. We must have firm moral bearings to give us strength in a world of shifting values.

8. Pupils must know Singapore's history, its vulnerabilities and constraints. They must develop a sense of shared identity and destiny, the instinct to defend Singapore's national interests, and the resolve and confidence to stand together as one people, to overcome threats and challenges.

9. Education helps to preserve our cultural roots. Our pupils ought to know their own cultural heritages and mother tongues. At the same time they must learn to understand and respect the different racial, religious, cultural and language backgrounds of their fellow citizens.

The Education System in Singapore

Education is a vital component of nation-building in Singapore. In keeping with the aim to nurture talent and develop individual potential to the fullest, the education system is geared towards providing at least ten years of general education for all children. The system also incorporates flexibility so that children of different abilities have the opportunity to develop themselves fully.

In educating our children, we are concerned that links with our roots are not neglected while keeping up with innovations and technological advances. Pupils learn at least two languages, English and their mother tongue in school. The mother tongue, which could be Chinese, Malay or Tamil, is given
prominence, as is English, the medium of instruction and language of administration, commerce and technology in Singapore. In this way, pupils keep in touch with their cultural links whilst being equipped with the skills to function in a modern, industrialised economy.

Special Programmes

In consonance with the Government's aim to nurture talent and maximise potential of pupils, the Ministry has, in recent years, introduced special programmes in schools. Such programmes include the Gifted Education Programme and the Science Research Programme.

Gifted Education

The Gifted Education programme is available in selected primary and secondary schools, to nurture the intellectually gifted. Apart from the extended syllabus and integrated approach, students learn skills for research and carry out independent studies. They are tutored by specialists in the Humanities and Sciences and receive personalised attention through smaller class sizes.

Science Research Programme

The main objective of the Science Research Programme is to give first-year junior college pupils with an aptitude for science the opportunity to participate in research projects under the guidance of lecturers from the National University of Singapore. The programme involves a science seminar which enables pupils to explore areas of scientific research with other pupils. Students also get the opportunity to visit research laboratories and attend talks by eminent scientists. Students work with a university mentor and are guided in experimental techniques and procedures. Their research findings are presented at an annual research congress.

It is also useful to find out what Singapore is planning in preparing for the Info-Society. There is an island-wide programme to lay cables to almost every home which will lead by next year to connections where Singaporeans can reach Web pages 1,000 times faster than today.

In preparing the population for the Info-Society, the Singapore government-backed National Computer Board has announced that it plans to ensure that:

- From next year, all primary school students will undergo basic computer training
- There will be a computer user in every home by the year 2000
- Every working Singaporean will know how to use computers by the year 2006

As model user/customer of the Information Highway, all Singapore government departments have begun launching Web sites through which its citizens can transact official business without leaving their homes or offices.

Another indication of Singapore's plans and future directions in the field of technology can be found in excerpts from the speech by Rear Admiral Teo Chee Hean, Singapore's Minister for Education at the launch of the Masterplan for Information Technology on April 28, 1997.

The underlying philosophy of the Masterplan is that education should continually anticipate the future needs of society, and work towards fulfilling those needs. The skills required for the future will centre on thinking skills, learning skills and communication skills. IT-based teaching and learning strategies will facilitate the development of these skills in our young as well as open possibilities for designing new curricula and methods of assessment to meet our educational objectives. IT will also enhance the effectiveness of educational administration, and encourage schools to communicate and collaborate with other institutions, and the community at large.

Currently, teachers from 22 Demonstration schools are undergoing training by Senior IT instructors from the Educational Technology Division of the Ministry of Education in core skills for using IT in their lessons. In 1998, teachers from about 90 schools will undergo training. Teachers from the remaining schools will receive training in 1999. By the year 2001, teachers in every school would have received substantial training and should be comfortable and competent in using IT as a teaching tool.

The Masterplan sets out national standards for the use of IT in schools by the year 2002. Schools will be given flexibility to determine how quickly they meet the national standards before 2002, depending on their readiness to use IT meaningfully to meet learning objectives. Initially, all primary schools
will be provided with the hardware and software required to allow IT-based learning for 10% of total curriculum time. Secondary schools and JCs will be given initial provisions, enabling IT to be used for roughly 14% of curriculum time. By the year 2002, the Masterplan envisages a pupil-computer ratio of 2:1 in every school, allowing for up to 30% of curriculum time to be IT-based. To enable teachers to have ready and frequent access to computers both during and after curriculum hours, the Masterplan will also equip schools with sufficient notebooks for use by teachers and complement this with a scheme to encourage teachers to purchase their own computers.

In addition to a range of support facilities, each school will be provided with an on-site full-time technology assistant to help the school handle problems in their use of hardware and software.

The Masterplan for IT in Education is integral to innovation in education to produce a workforce of excellence in the 21st Century. It is a major and worthwhile investment in our young and in our future.

The World Has Changed

Today, primary school students in Singapore are communicating with primary school students in the UK and with a British aircraft carrier, keeping track of her progress as she makes her way half way round the world. They are learning about life on board the ship, and about the various ports she is visiting on this journey - for the students from these two schools and the sailors on board it is also a journey of mutual discovery.

The world has changed. Technology has changed it. We are now able to reach out from our schoolrooms to any place in this world. The only fences are in our minds.

Information technology [IT] has made it possible for us to connect and work with more people and in more locations around the world. Our world has shrunk; and so must our minds expand to learn to take in all that is now within our reach.

Human Resources for the Future

To thrive in this future world of the 21st Century, Singaporeans must learn to think beyond the bounds of their physical surroundings - beyond home and school, to the community, our country, our region and the wider world. Singaporeans must also learn to think beyond the obvious, to think creatively, to search for new knowledge, to come up with new ideas. They must be comfortable with new technologies and be able to exploit these new technologies to venture beyond their current boundaries and open up new frontiers of knowledge.

Mastering technology and harnessing it for widespread and comprehensive use in a society is not an easy task. More so when technology is progressing and changing rapidly. Nowhere is this more true than in the area of information technology.

The IT revolution is already well underway. It is changing the way we live - the way we work, study and play. The next century will witness the increasing use of information and knowledge as engines of productivity and economic growth. We have to prepare ourselves and our children to be discerning and astute users of information as well as creators of knowledge.

Preparing the younger generation

Governments in developed countries all over the world recognise that the ability of their people to continually master new technologies will have a critical impact on their future global competitiveness. These governments know that education is the key.

The United States has established a $200 million Technology Literacy Challenge Fund which will give American students access to computers. Over 6000 schools will be linked. [ASCD Report, Jan 97]

In Europe, getting "every school and every school kid on the Internet" is the new manifesto of European politicians. [Cybertimes, 1 Apr 97]

The major European countries - Germany, France, Britain, Italy have all announced major programmes for Information Technology in education. For example, Italy has just launched an
ambitious programme to install multimedia workstations and Internet connections in 15,000 schools by the year 2000, with an investment of about S$850 million.

Finland, with a population of just 5 million has launched a 5-year plan, for a national strategy in "Education, Training and Research in the Information Society". Finland is already the country with the highest connections to Internet in the world, (in terms of number of hosts per 1000 people as reported by the World Competitiveness Yearbook).

In Asia, Japan also has similar programmes.

These initiatives in the most advanced nations reflect their governments' desire to use IT in education in order to build an information-rich community and to stay ahead. Developing countries are also realising the importance and the potential of IT.

Harnessing IT for education

Singapore's Masterplan for IT in Education lays out a comprehensive strategy for creating an IT-based teaching and learning environment in every school. It will be one of our key strategies for equipping our young with the skills that are critical for the future - creative thinking, the ability to learn independently and continuously, and effective communication.

Our Masterplan for IT in Education will have four goals. First, to enhance linkages between the school and the world around it, so as to expand and enrich the learning environment. Second, to encourage creative thinking and lifelong learning. Third, to encourage innovative processes in education, and fourth, to promote administrative and management excellence in our education system.

The Masterplan will be part of our education programme for the nation. We want the computer revolution to reach every child whether or not he can afford to have a computer at home. We want every child to be proficient in the use of computers and benefit from learning in an IT-enriched environment.

Today all our schools are already equipped with computers - a typical primary school with 100 and a typical secondary school with at least 40. Many have more. Every school is connected to the Internet. 17,000 teachers have Internet accounts. We want to make our schools even smarter.

As a small and compact country we can respond more quickly and flexibly to change than bigger countries. We should capitalise on this advantage to achieve the goals of this programme as quickly as possible for the benefit of all our students.

The target for our Masterplan, to be achieved by the year 2002, is for students to have hands-on use of computers for 30% of their curriculum time. This means providing 1 computer for every 2 pupils.

In addition, every school will be fully networked allowing teachers and pupils to access courseware, the Internet and digitised media resources from every classroom, and from all learning areas. This will also encourage the sharing of teaching resources within and between schools.

The target of 1 computer for every two students is the norm that we will work towards. Some schools will reach these standards before the year 2002 depending on how fast the schools themselves can integrate the use of IT.

For a start we will increase the number of computers in every school so that students can use computers for 10% of the curriculum time. This will be achieved within the next three years. Within three years, there will be 1 computer for every 6 to 7 primary school pupils and 1 computer for every 5 secondary school or junior college students. We will also provide every school with one computer for every two teachers. A typical primary school will therefore have at least 150 computers, and a typical secondary school 340 by 1999.

The targeted percentages of curriculum time are based on the experience gained over the last one to two years in our pilot projects in 12 primary and secondary schools.

Teachers are the key to the success of this programme. The Masterplan therefore provides for a comprehensive teacher-training programme - all teachers will be trained to use IT in their lessons by 1999. New teachers undergoing training in the National Institute of Education already learn how to make use of IT for teaching as a standard part of their course.
In addition to providing the schools with one computer for every two teachers, we will give teachers a grant worth 20% of the cost of a computer to buy their own computers. Every teacher will have an Internet account. We want to encourage high ownership and usage of computers among teachers because the computer will be an indispensable tool for teaching. Teachers will come to use the computer for preparing their lessons, for teaching in the classroom, for going through their pupils' work and for communication with their pupils, their peers and the Ministry.

**Resources required**

The Masterplan for IT in education will require significant additional resources to be devoted to education. The government will commit $2 billion from 1997 to 2002 to implement this programme. This includes funds for computers, full networking of the schools, physical renovations, software and courseware, and teacher training.

Subsequently, another $600 million a year will be provided to maintain and replace hardware, develop new software, and for the continuous training of teachers.

We will also invite private sector participation not only as suppliers of hardware, but more importantly, as content providers. This is a major programme and my Ministry will not be able to develop all the required courseware and resource materials on its own; nor is trying to do this on our own the best strategy for my Ministry to adopt.

We want the private sector to be active participants in this programme and help to provide the expertise. Our wide scale implementation of this programme will provide many opportunities for the industry to introduce new technology and ideas. We hope that this Masterplan will spur the growth of a major new industry in Singapore that will provide educational software and educational content.

The Ministry will also be guided by an Advisory Council on IT in Education comprising local and overseas experts who will advise us on the implementation of the Masterplan.

The Masterplan is a very comprehensive one that will cover all schools and all students. Though Singapore is a small country, the overall scale of this programme is larger than that envisaged in countries that are much bigger than Singapore. The Masterplan will provide a computer to student ratio, and proportion of computer usage throughout the school system that is at least comparable and in many cases beyond what the developed countries are planning to do. This will help our students, our workforce and our country remain in the top league of competitiveness.

Singapore is able to implement such a comprehensive programme in such a short time for three reasons:

First, it is a small country, more tightly knit and better organised. Implementers can reach all the schools and complete the programme more quickly and easily than in a bigger country.

Second, Singapore has used its resources wisely, exercising fiscal prudence, spending wisely and avoiding unnecessary expenditures. The country is hence able to put aside enough resources in every year's budget to support such a major programme.

Third, the country has strong foundations. The education system works well, teachers are well trained and motivated, and they are receptive to new technology. As a nation, Singapore has emphasised IT for more than a decade and a half - since the early 1980s. Home ownership of computers is high, and so is computer usage in the workplace. Many Singaporeans are computer literate and comfortable with computers.

**The Role of Principals and Teachers**

Computers cannot replace principals and teachers. Computers are tools for the principal, for teachers and for the students to enhance their work and facilitate learning.

For example, our pilot projects in the schools reveal that the use of computers can motivate pupils to be more interested in their studies. The brighter pupils used IT to go beyond curricular objectives and become more independent learners. Less able pupils showed greater interest in their studies and, encouraged by hands-on lessons, performed better.
The IT Masterplan is a great opportunity for teaching professionals like yourselves to exercise your creativity and devise ways of using this powerful new tool to enrich the lives of young people under your care.

We have a good education system. Our achievements are the result of the hard work of our students and teachers, and the reforms that were put in place in our education system in the past.

The IT Masterplan will open new frontiers in our education system. We must exploit the full potential of IT to ensure that we educate our children to be among the best in the world.

Our schools must be plugged into this more competitive, more interconnected world. Our schools must adapt and change. But our schools must still continue to provide a cozy and nurturing environment for our children, just as they always have. And you as principals and teachers must continue to guide them and help them grow for committed principals and teachers will always be the heart and soul of our education system.

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In addition to a range of support facilities, each school will be provided with an on-site full-time technology assistant to help the school handle problems in their use of hardware and software.

The Masterplan for IT in Education is integral to innovation in education to produce a workforce of excellence in the 21st Century. It is a major and worthwhile investment in our young and in our future.

In the 1995 National Computer Board survey, 358 organisations employing a total of 9,070 IT employees participated in the IT Organisation Survey. At the same time, 4,192 individual responses were received for the IT Manpower Survey. The survey estimated that the number of IT professionals in 1995 stood at 21,000, compared to some 14,300 in 1991. This represented a 47 percent growth over four years. The growth of IT manpower in the public sector was also seen to have levelled off, while the IT user and IT supplier sectors were shown to be experiencing rapid growth. The estimated growth rate for IT manpower between 1995 and 1997 is 13 - 15 percent per year.

The survey also highlighted the following two findings:

a. the high cost of training was the top issue faced by organisations in IT manpower planning, and b. there was a demand for training in key areas such as client-server, networking, multimedia, object-oriented programming and project management.
In response to the findings, a S$6-million Critical IT Resource Programme (CITREP) was set up to support 50 percent of the course fee and/or examination fee of NCB-endorsed training programmes for such skills. To date, 41 training programmes have been endorsed under CITREP. Some S$1m has been committed to support over 500 IT employees under CITREP.

The NCB recognises that having an appropriately skilled pool of IT manpower is critical for realising the IT2000 vision. The Board is continually seeking to identify the concerns and issues of IT employees. It will recommend and implement policies and programmes that will enhance their performance and effectiveness. This is to ensure that Singapore's IT manpower is equipped with the skills to meet the challenges ahead, and is continually upgraded through training and re-training to stay ahead of technological developments.

**National Computer Board**

Too small to rely on its own resources, Singapore has always plugged into global networks. The Intelligent Island vision will help turn Singapore into a highly efficient switching centre for goods, services, capital, information and people. Singapore will be further developed as a hub for business, services and transportation. Companies with global operations and specialists who want to market their expertise worldwide will find Singapore an attractive base. Knowledge and information-intensive services can be provided from Singapore to points around the globe.

**Improving the Quality of Life**

Making work more efficient and chores less time-consuming will increase discretionary time. Singaporeans will have more time to spend on leisure, kinship, social and civic pursuits. People will be able to handle transactions with government agencies or private businesses electronically. Examples include paying bills, submitting applications and routine shopping. Booking tickets for sports and cultural events, restaurants and shows, accessing vast video and reading libraries, browsing through the world's renowned museums and art galleries, communicating with friends and family, and deciding on holidays will be made easy through multimedia and other technologies in the Intelligent Island.

**Boosting the Economic Engine**

The potential benefits to the economy are immense. Information is becoming a critical factor of production providing many industries with the impetus to enhance their competitiveness. It is transforming the economy. For example, innovative exploitation of IT can help Singapore develop high value-added manufacturing with links to lower cost manufacturing centres in the region and markets around the world. Commerce can be boosted by increasing Singapore's efficiency as a regional distribution centre and in retailing. The construction industry can use the fast and efficient exchange of information, documentation and drawings to improve competitiveness and at the same time, foster local and international collaborations.

**Linking Communities Locally and Globally**

The Vision of the Intelligent Island knows no boundaries. It will help strengthen social bonds among our people by electronically linking like-minded people, or those with a common cause or interest. Individuals will be able to form their own communication links be it the clan, the reservist unit, the old school tie, a professional society, lonely hearts club or resident's committee. The nationwide infrastructure has the ability to cross geographical and cultural boundaries so that Singaporeans will be able to see and talk to people around the globe from their home or office. People residing abroad, especially Singaporeans and friends of Singapore, will be able to access the nationwide information infrastructure to keep in touch with people and events in Singapore.

**Enhancing the Potential of Individuals**

In the years ahead, skills, creativity and knowledge will become even more important for success. Workers will need to be re-trained and re-skilled continuously to keep pace with changes in their working lives. In the Intelligent Island, people who want to acquire a new capability, say learning a new language, can do so in novel and interactive ways. Distance learners will be able to use their computers to learn at their own pace and at a time and place of their choice. New teaching methods will make learning more interesting with the use of multimedia learning packages and aids. IT will
also help enhance the capability of the physically handicapped. For instance, video conferencing will allow the deaf to "talk" over distance.

This travelling exhibition was introduced in 1995 by the NCB. As we move towards a society of advanced information technology, it is part of the NCB’s ongoing effort at creating public awareness and also a more IT fluent society to support the IT2000 vision of turning Singapore into an Intelligent Island. Six similar roadshows organised last year attracted more than 30,000 visitors. Riding on last year’s success, this year’s computer carnival will be going to six shopping malls. Set in a fun atmosphere, the computer carnival will highlight the value and versatility of IT solutions for the home. The exhibits will show how families can use the computer to learn new things, search for information and pursue fun hobbies.

Today, it is no longer enough to have an understanding of the use of computers. Singaporeans of all ages must learn to make full use of IT services. In today’s information age, we must master the ability to collect information, process, and transform such information into useful knowledge for our advantage. In time to come, we will surely see that those who have the willingness and the ability to do this will have an advantage over those who don’t.

By the end of 1997, all primary school pupils will use computers in the classroom. Although most children will have an opportunity to use computers in their schools, the hands-on time is usually limited. It would be much better if children have access to a computer at home. They could then work on their projects and assignments, communicate with their classmates and explore the Internet, at their own pace. A wide range of educational CD-ROM titles with pictures, sound effects, and engaging animations are available to help our children improve language and mathematical skills, nurture creative thinking and sharpen problem solving skills. As parents today, we have to catch up and learn about the various types of educational software and information services that will benefit our children. We can then play an active role in finding the right software to suit our children’s development and help them get the most out of the home computer.

Singapore’s IT2000 plan envisions a fully networked society, with computers linking our homes, schools and offices. The potential of IT will likely change the way we live, work and play. Today, we can obtain useful library information services and access all types of databases, ranging from art to science, conveniently from home. With mobile office solutions, working adults can choose to work from their home offices giving them the flexibility to spend more time with the family. With the Internet, on-line shopping gives a totally new experience to armchair shoppers.

The 1996 IT Household Survey showed that three out of ten households in Singapore own a computer. With increasing affordability of computers, the number of Singaporeans buying home computers is also rising quickly. However, there are still some who see IT as something alien and difficult to use. For this group of Singaporeans, I hope they can take time to attend the exhibition and see how easy it is to use a PC and to try out some of the IT solutions.

Indeed, IT will play a very critical role in our nation’s progress. With close to a third of our workers being non-IT literate, there is an even greater impetus for us to promote IT. I am confident that the Computer Carnival will play a significant role in bringing IT to everyone, encouraging the young and old to embrace IT as a way of life.

Singapore’s achievement in the third international mathematics and science study (TIMSS)

Overall achievement

1 Singapore shared the top spot with Korea in mathematics and was seventh in science in an international study for 9-year-old students. This study, known as the Third International Mathematics and Science Study (TIMSS), is the largest international study of standards of performance in mathematics and science conducted to date.

2 The study was conducted by the International Association for the Evaluation of Educational Achievement (IEA). IEA is an international authority on the study of educational standards and it has 53 institutional members including countries like Singapore, the United States, France, Germany and Japan. Its headquarters is in Amsterdam, the Netherlands.

3 In October 1994, 14,500 9-year-old students in Pri 3 and Pri 4, and 8,500
13-year-old students in Sec 1 and 2 in Singapore sat for tests in mathematics and science, along with half a million students from 44 other countries.

4 For the 9-year-olds, Asian students generally did very well in the mathematics section, with Singapore, Korea, Japan and Hong Kong occupying the top positions. For science, the Asian countries continued to do well, with Korea and Japan at the top of the table while Singapore was seventh. Science is taught only from Pri 3 in Singapore, compared with most of the other participating countries which begin teaching science from the first grade.

5 Singapore students have done well in the TIMSS tests for 9-year-old students.
   - At both Pri 3 and Pri 4, almost 40% of the students in Singapore were placed in the top 10% for mathematics; for science, 11% of our students were placed in the top 10%.
   - In mathematics, the Pri 3 students in Singapore obtained correct answers to 62% of the questions compared to the international average of 47%. The Pri 4 students did equally well, with 76% correct answers compared to 59% at the international level.
   - In science, the Pri 3 students in Singapore obtained correct answers to 53% of the questions compared to the international average of 50%. The Pri 4 students obtained 64% correct answers compared to 59% at the international level.

Other Key Findings

Increase in Performance

6 In the TIMSS results for grades 7 and 8 (i.e. Sec 1 and 2 in Singapore) released in November 1996, Singapore was top in mathematics and science for both grades. Based on the performance of students in both grades 4 and 8, the study estimated the increase in mathematics and science achievement between the two grades. Singapore's estimated increase was among the largest for mathematics and science. The performance increase of Singapore's students indicates that delaying the learning of science to Pri 3, so as to give more time to the learning of the languages and mathematics in Pri 1 and 2, did not disadvantage pupils subsequently as they advance through the school system in Singapore.

Statement by the Minister for Education

Shaping up the Education Service for the 21st Century

Education is crucial to Singapore's continuing success. The Government has invested heavily to develop an outstanding education system for Singapore. School facilities today are much improved compared with 10 years ago, and much better than in many other countries. We will continue to invest in better schools and equip them with the latest educational technology.

Promoting S&T to the young (PSTY) is a framework which aims to enhance the interest and raise the awareness of the importance of S&T to our students.

Numerous programmes have been developed ranging from:

- Student seminars quizzes exhibitions and fairs
- Award for research work
- Award for innovations

Together with tertiary institutions, NSTB also works towards enhancing the training of undergraduates and postgraduates so as to give them a grounding in science and engineering for a career in R&D.

Examples of these programmes are

- National Undergraduates Research Programmes
- Top-up Scheme for Local Postgraduates and
- Postgraduate Training Initiatives Specially for students:

Student seminars, quizzes and exhibitions are organized to raise the level of S&T among students.
Seminars are conducted regularly throughout the year covering topics ranging from innovation, to careers in R&D to latest development in virtual reality.

Quizzes like the HP Technology Quiz aim to promote awareness of technology amongst Singapore's future leaders.

It is open to students from all Junior Colleges in Singapore and the annual event is co-organised by the National University of Singapore, Nanyang Technological University, Hewlett Packard Singapore (Pte) Ltd, Singapore Academy of Science together with NSTB.

NSTB works with organisations like Singapore Science Centre, the tertiary institutions and various organisations like the National Science Teachers' Association and the Singapore National Academy of Science to organise promotional events like exhibitions and fairs.

Activities include the event called Science, Technology and Engineering for Progress '96 (STEP '96) in September 1996 and the Brain Opera to be held in December 1996.

**Award for research work - national science talent search (NSTS)**

The NSTS Award aims to identify and accord recognition to aspiring students with the strongest aptitude for science and research.

It is open to Secondary School and Junior College students who are Singaporeans or Permanent Residents between the age of 15 to 18 years. Participants must submit a complete Science or Engineering research project.

Winner(s) will receive a $10,000 grant for S&T activities such as educational tours to overseas universities, a scholarship offer to either local or overseas universities, a trophy and a certificate.

Merit Awards will be given to commendable participants, where they will receive a local scholarship, a certificate and $500 cash prizes.

- The NSTS Award on 12 April 1997.
- The Inaugural NSTS Award on 9 March 1996.

**Award for innovation - Tan Kah Kee (TKK) Young Inventors' Award**

The TKK Young Inventors' Award was launched as an annual event in May 1986. From 1995, NSTB will be co-organising this annual event with the TKK Foundation.

This award, divided into the students' and open section, looks for inventions that are original, practical and which can be commercialised into products.

**National Undergraduate Research Programme**

This initiative aims to support the undergraduate research programme in the two local universities by providing a grant to help fund the cost incurred by the undergraduates for their research projects.

The undergraduates will present their research findings at a National Congress targeted at all Science and Engineering undergraduates, Junior College and Secondary school students to encourage the development of the research culture in Singapore. TOP-UP SCHEME FOR LOCAL POSTGRADUATES

The scheme is set up with the objective of encouraging the local graduates in Singapore to pursue postgraduate research in the local universities in areas of technology which are critically in need of manpower.

Candidates are offered an additional allowance over and above the monthly stipends received from the universities' research scholarship.

**Postgraduate Training Initiatives**

Similar to the Top-up scheme for local postgraduates, this is another means to meet the skill demands of the industry, especially in the areas of technology where there is a critical need for highly trained manpower.
The scheme aims to encourage the final year undergraduates to continue to full-time postgraduate training.

It covers an undergraduate's tuition fees and a monthly allowance for the duration of the final year of study in the local universities. Recipients of this scheme will then be obliged to work in a R&D or related capacity. Singapore's tertiary institutions are currently training graduates with a strong grounding in science and engineering. Each year, about 10% of science and engineering graduates take up R&D career in Singapore.

The training of research scientists and engineers (RSEs) is facilitated under NSTB's Manpower Development Assistance Scheme (MDAS). These programmes are designed to enhance the skills and increase the number of RSEs in Singapore.

To accord greater recognition to outstanding RSEs, three prestigious National Science & Technology Awards (NSTA) are given during TechMonth, an annual event that serves to promote public awareness of the importance of S&T to economic development.

MDAS assists industry to train and upgrade their research personnel. These include:

- Joint Industry Study Grant (JISG)
- Research Exchange Programme (REX)
- Foreign Researchers Recruitment Programme (FRRP)
- Adjunct Appointment for R&D

Joint Industry Study Grant (JISG)

JISG is established to train and upgrade existing and potential R&D personnel through Masters and Ph.D courses offered by both local or overseas universities.

JISG funds 70% of tuition and other compulsory fees. The company will sponsor the other 30%. In addition, allowances will also be provided during the course. JISG is for Singaporean or permanent resident who wish to pursue higher degree courses in Science, Engineering or Management of Technology.

Research Exchange Programme (REX)

REX serves to encourage technology transfer through attachment of research personnel.

Under the REX Overseas Programme, company's R&D staff can be sent overseas for training or experienced overseas trainers can be brought in to train their local R&D staff.

The REX Local Programme funds companies that attach their R&D staff to local universities and research institutes/centres. Experienced researchers from these organisations can also work on R&D projects in the company.

If your company wishes to strengthen its technological capability through overseas or local technology transfer, REX is applicable.

Adjunct Appointments for R&D

A company may want to attach experienced researchers to co-supervise students, provide inputs regarding research directions and participate in collaborative research projects with the university.

The Adjunct appointees, whose remuneration is based on the university's structure, will be attached to the universities eight hours per week.

Three prestigious national awards are presented during TechMonth to recognise contributions of eminent researchers and scientists.

- The National Science Award (NSA)
- The National Technology Award (NTA)
- The National Science and Technology Medal (NSTM)

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The National Science Award (NSA)
The NSA is awarded to RSEs who have made outstanding contributions in basic research leading to an important discovery or the pioneering development of scientific/engineering techniques and methods.

The two teams that have been awarded the prestigious NSA in 1996 are
- Dr Tay Sun Kuie, Dr Ang Peng Tiam and Dr Hui Kam Man, for their outstanding contributions in research of gene immunotherapy in gynaecological cancers; and
- A/Prof Kang En Tang, A/Prof Neoh Koon Gee and Prof Tan Kuang Lee, for their outstanding contributions in photoelectron spectroscopic investigations of the structures and properties of polymers. <Picture: Science & Technology Promotion>

The National Technology Award (NTA)
The NTA is awarded to accord recognition to RSEs who have made outstanding contributions to applied R&D, resulting in industrial application. It aims to encourage pioneering development of important industrial processes or improved industrial products, employing innovative technology that has potential for commercialisation.

The team that was awarded the 1996 NTA was - Mr Daniel Lau Chin Hua, Mr He Liang, Mr Yuan Baosheng and Mr Li Zhiwei, for their outstanding contributions in the development of the Chinese Dictation Kit'.
- Mr Daniel Lau Chin Hua, Mr He Liang, Mr Yuan Baosheng and Mr Li Zhiwei, for their outstanding contributions in the development of the Chinese Dictation Kit'.

The National Science & Technology Medal (NSTM)
The NSTM accords recognition and appreciation to distinguished individuals for their contribution to Singapore’s growth and development through the promotion and management of R&D.

The two winners of the 1995 NSTM were
- Dr Herbert Eleuterio, for his outstanding contribution and guidance in the development of S&T and
- Dr Goh Hak Su, for his outstanding contribution and guidance in promoting colorectal cancer research.

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National University of Singapore

Mission
As the premier tertiary institution in Singapore, the National University of Singapore (NUS) is committed to support the nation’s social and economic development by:
(a) Producing graduates with the requisite knowledge and skills, capable of independent lifelong learning and adapting to changing circumstances; and
(b) Developing their creative potential and promoting research and innovation.

Staff Student Strength
In 1996 the University has 2,318 (22.6% women), full time staff and 60 (21.7% women) part time staff. There are 17,109 undergraduates and 3,737 postgraduates.

Among the undergraduates, 43.7% are in the Faculties of Science and Engineering. The Science Faculty has a student number of 4,757 (undergraduates), which is the second largest (next to Faculty of Arts & Social Sciences) among the eight faculties.
Research

Research is given top priority in NUS. This is reflected in the more than 1,500 ongoing research projects carried out by the academic community of about 1,600 teaching staff and 800 full-time research staff.

In line with the national emphasis on the development of high technology and knowledge-intensive economy in Singapore, the University's Institute of Systems Science (set up in 1981), Institute of Molecular and Cell Biology (1987), Institute of Microelectronics (1990), and the National Supercomputing Research Centre (1993) have made important contributions to the advancement of information technology, biotechnology, microelectronics technology, and advanced computational technology in Singapore. The National University Medical Institutes (NUMI) was established in 1994 to strengthen the research capabilities of the Medical Faculty while the Institute of Molecular Agrobiology (1995) will undertake innovative world-class research in agrobiology at the genetic and molecular levels.

Beside these six speciality research institutes/centres, there are several other research centres established in the various faculties and institutes to spearhead R & D for specific applications in industry and business. In the Faculty of Science, there are

(i) Bioscience Centre and (ii) Centre for Remote Imaging, Sensing and Processing. In the Faculty of Engineering, there are 18 research centres covering area such as optoelectronics, intelligent control, computational mechanics, bioprocessing technology etc. In the Institute of Molecular and Cell Biology, there is Centre for Natural Product Research. In the Institute of Systems Science, there are (i) Apple-ISS Research Centre and (ii) ISS-Johns Hopkins Centre for Information-enhanced Medicine.

In 1996, there were 453 postgraduate students in the Faculty of Science, 536 in Faculty of Engineering, 563 in Postgraduate School of Engineering, 31 in Institute of Molecular and Cell Biology, 180 in Institute of Systems Science. These constitute 47% of the total postgraduate population in NUS.

Industrial Collaboration

NUS contributes to the economic well-being of the country by supplying industry with well-trained R & D manpower in sufficient numbers to meet the nation's socioeconomic needs, and producing research ideas and findings with potential for commercial development. The Industry and Technology Relations Office (INTRO) was established in 1992 as a one-stop information and service centre for industry and organisations seeking collaboration. NUS Technology Holdings Pte Ltd, a private company wholly owned by the University, was established in 1995 to further facilitate the commercialisation of University research results and inventions.

Academic Linkages with Overseas Universities

NUS has established links with more than 60 renowned institutions in the USA, UK, Canada, Australia, New Zealand, Belgium, France, Germany, Norway, Sweden, Denmark, Portugal, the Netherlands, Hong Kong, Japan, South Korea, Taiwan, and the PRC.

Links with School

The Faculty of Science has been organising the Science Research Programme jointly with the Gifted Education Unit of the Ministry of Education for a decade. It accepts a number of students from the junior colleges to come to NUS to do research projects with the staff. We also have the Science Mentorship Programme and the Science Camp which cater to the gifted secondary school students. The Science Vision Programme brings a large group of students from the junior colleges to the University for innovative talks, demonstrations and laboratory-based learning. We also work with the Ministry of Education to organise and host the Singapore Chemistry Olympiad, Singapore Physics Olympiad and Singapore Mathematics Olympiads. These Olympiads are national projects which are well publicised. Special training and coaching are conducted by staff members to prepare the national teams to compete in the international Olympiads in chemistry, physics and mathematics.
In Singapore, the national focus on science and technology has been extremely strong and within the last decade this has also embraced the area of the computer and information technology. This has meant great emphasis on science education throughout the nation-state.

Reasons for Singapore's successful inculcation of scientific and technological culture include the strong national commitment backed by technological, training and personnel resources in this field, an examination system throughout schools and higher institutions of learning with emphasis on science and technology, efforts to popularise science and technology outside the education system and strong links between industry and the training institutions.

This paper will deal primarily with science and technology training, research and activities outside the school system. My colleagues from the National University of Singapore, National Institute of Education, the Singapore Science Centre and the Science and Technology Board will join me in giving you an idea of the training, research and popularisation in science and technology in their institutions while I will deal very briefly with Nanyang Technological University's activity in this area.

The official discourse articulates a vision of NTU as the MIT of Asia. NTU's mission is to train leaders, professionals and entrepreneurs for Singapore and the region and to advance research and development in both academic and professional disciplines.

It offers undergraduate degree courses as well as postgraduate programmes by coursework and by research. The University has two campuses.

The Yunnan Garden Campus consists of six faculties:
- School of Accountancy and Business
- School of Applied Science
- School of Civil and Structural Engineering
- School of Electrical and Electronic Engineering
- School of Mechanical and Production Engineering
- School of Communication Studies

Its Bukit Timah Campus constituting the National Institute of Education (NIE) consists of:
- School of Arts
- School of Science
- School of Education
- School of Physical Education

Research and Development

To facilitate research and advanced training, various research institutes and centres of excellence are set up at the University. They include 16 institutes and centres based outside the Schools.

These are:
- Gintic Institute of Manufacturing Technology
- NTU-CIDB Centre for Advanced Construction Studies (CACS)
- Entrepreneurship Development Centre (ENDEC)
- NTU-DIGITAL Network Technology Research Centre (CGIT)
- NTU-PWD Geotechnical Research Centre
- Robotics Research Centre
- NTU-CSP Centre for Signal Processing
- Asian Commerce and Economics Studies Centre (ACES)
- Centre for Accounting and Auditing Research (CAAR)
- Centre for Research in Financial Service (CREFS)
- Entrepreneurship Development Centre (IMARC)
- School of Accountancy and Business Research Centre (SABRE)
To encourage local and locally-based enterprises to carry out their R & D activities on campus where expertise of NTU staff and facilities are readily available and where students could be involved in such activities, the University has set up an Innovation Centre which is a mini Science Park.

Research and development form an important part of the activities of the University. The University encourages its staff to do R&D work as well as provide consultancy services to industry and business in their areas of expertise. Funds are provided in the annual budget for staff to carry out approved research projects. Research fellows and other research staff are also appointed to spearhead and assist in research activities.

**Schools**

The Schools with a main emphasis on Science and Technology includes the Engineering Schools, the School of Applied Science and the School of Science (NIE). The School of Communication Studies has also placed strong emphasis on technology in its media production courses. The primary functions of the School of Mechanical & Production Engineering (MPE) are to train and educate professional mechanical and production engineers and to advance the state of knowledge in important mechanical and production engineering fields. The School currently has more than one hundred academic staff members and is organised into four Divisions to facilitate the coordination of various academic and research activities. These are the Division of Engineering Mechanics, Division of Thermal and Fluids Engineering, Division of Manufacturing Engineering, and Division of Systems & Engineering Management.

The School of Civil and Structural Engineering's (CSE) primary functions are to train and educate professional civil and structural engineers, and to advance the state of knowledge in important civil and structural engineering fields. The School has currently 85 academic staff members and about an equal number of technical and clerical staff.

To facilitate the coordination of various academic and research activities, the School is divided into three divisions:

- Geotechnics and Surveying Structures
- Construction Water Resources and Transportation

The School of Electrical and Electronic Engineering (EEE) was one of the three founding Schools with which Nanyang Technological Institute (now Nanyang Technological University) commenced its undergraduate courses in engineering, soon after it was set up in August 1981. The first batch of students to obtain the BEng (Electrical) degree graduated in 1985. The number of graduates has steadily increased over the years, from 194 in 1985 to 641 in 1996.

In addition to its undergraduate programme, the School now has postgraduate programmes leading to the MSc degree by course work and dissertation, and MEng and PhD degrees by research. The School aims to have about 25% of the total student enrolment as postgraduate research students.

The School of Applied Science was established in 1989 to offer specialised courses that meet the ever expanding needs of Singapore in the area of information technology. To cater to these needs, the School offered its first undergraduate course, Computer Technology, which has since changed its name to Computer Engineering.

While the Schools of Civil, Mechanical and Electrical Engineering offer traditional disciplines, the School of Applied Science sets out to define new and emerging paradigms for the 21st century. Currently, the teaching and research activities of the School take place within its following four divisions:

**Computing Engineering (CE) Course administered by:**

- The Division of Computing Systems (CS)
- The Division of Software Systems (SS)

**Materials Engineering (ME) Course administered by:**

- The Division of Information Studies (IS)

The Computer Engineering course has been fully accredited by the Institution of Engineers, Singapore & recognised by the Professional Engineers Board of Singapore.
The Materials Engineering course has also been fully accredited by the Institution of Materials Engineers (UK), Institution of Engineers (Singapore) and recognised by the Professional Engineers Board of Singapore.

The School of Communication Studies offers a four-year programme leading to a Bachelor's degree (with Honours) in Communication Studies.

It prepares students to design, manage and assess media and information systems to serve government, industry and the public in a rapidly changing communication environment. Students are required to complete a number of core subjects and prescribed electives in the first and second years of their study.

In the third and fourth years, they specialise in one of the following four divisions of the School:

(one) Division of Journalism and Publishing
(two) Division of Electronic and Broadcast Media
(three) Division of Public and Promotional Communication; and
(four) Division of Communication Research.

The Master of Mass Communication programme is designed for those planning a career or already working in the communication industry. A balanced curriculum challenges students to confront contemporary issues in media theory, research, policy, planning and management with an emphasis on Singapore and Asia. Course concentrations and individual subjects address the needs of those working in both the public and private sectors. The programme provides concentrations in:

(one) Media Management and Marketing
(two) Communication, Technology and Society
(three) Public and Persuasive Communication

A thesis/project is required in which students apply the concepts and issues discussed in coursework. The aim of the programme is to prepare students for leadership positions in their chosen area in communication.

The School has established close links with the media and communication industries. Professional organisations such as the Singapore Press Holdings, Television Corporation of Singapore, Radio Corporation of Singapore, Singapore CableVision, Singapore Book Publishers Association, the Institute of Public Relations and the Association of Accredited Advertising Agencies are involved with the School through their representation on the Advisory Committee, sponsorship of scholarships and awards, assistance with the students' internship programmes and support for student activities.

National Institute of Education

The main mission of the NIE is to educate teachers for the Singapore School System and the Science and Mathematics components of teacher education comes under the responsibility of the School of Science. Through our various programmes, we seek to produce teachers who are able to communicate an enthusiasm for Science and Mathematics to their students throughout Singapore.

The School of Science promotes Science on three fronts: (i) through teaching methodology courses in Science and Mathematics Education, (ii) through the teaching of pure science content courses in the subject areas of Biology, Chemistry, Mathematics and Physics and (iii) through Research in the Scientific and Education fields.

The School conducts methodology courses in the teaching of Primary Science and Mathematics and in the teaching of Mathematics and Science subjects at the secondary level in the initial teacher training programmes. Numerous school workshops and in-service science and mathematics courses for teachers are also conducted by staff of the School and these contribute to the further professional development of Science and Mathematics teachers. All these courses are built upon the underlying philosophy that Scientific concepts and procedures should be made comprehensible yet challenging to young minds and should be related to the world beyond the classroom.
In our degree programme, undergraduates also read the pure content subjects of Biology, Chemistry, Mathematics and Physics. Here, a scientific culture is imbibed through not only learning the concepts and modes of scientific enquiry but applying these to enhance the world around us. Modules in all the subjects are designed with emphasis on applications and teaching approaches include field trips, and the appropriate use of Information Technology and multi-media.

In the area of Research, academic staff not only carry out scientific research in their own areas of interest and supervise postgraduate students in research, students at undergraduate, junior colleges and secondary levels are given partnerships in research through four programmes: (a) the National Undergraduate Research Programme (NURP) for our own undergraduates, (b) the Technology and Engineering Research Programme (TERP) for Junior College students, (c) the NTU Science Mentorship Programme for Gifted Education Programme students from Secondary Schools and (d) an informal programme where academic staff guide teams of secondary school students through small research projects at the request of science teachers.

The academic staff of the School of Science have been invited on numerous occasions to give talks on Science and Mathematics to schools and junior colleges on an ad hoc basis. We have also organised a seminar for Junior College students where highlights of research projects and their applications were presented. All these talks and seminars serve to demystify what Science is about as well as bring across the usefulness and relevance of science to the school level students.

The School has working links with the National Science and Technology Board which sponsors some of the above projects and with the Singapore Science Centre.

Staff are represented on Science Centre committees and a Science Centre visit to acquaint our trainee teachers with the resources there is part of our methodology courses. Staff also work together with various scientific bodies such as the Singapore National Academy of Science and its constituent members, especially the Institute of Physics, Singapore, the Science Teachers Association of Singapore, the Singapore Institute of Biology, the Singapore Mathematical Society and the Singapore National Institute of Chemistry. The Association of Mathematics Educators which promotes mathematics education to teachers, education professionals as well as parents is also strongly associated with the School of Science.

Singapore Science Centre

Objectives and Roles of the Science Centre

Singapore Science Centre is a Statutory Board under the purview of the Ministry of Education. It is a non-formal educational institution for the promotion of science and technology among students and members of the public. The Centre was founded in 1970 with the following mission objectives:

(a) To disseminate knowledge in science and technology to the public and students in particular in an imaginative and enjoyable fashion so that they can appreciate the relevance of science in their lives;
(b) To serve as a catalyst for our youths to develop their creativity and to nurture their interest in related fields; and
(c) To establish a centre of excellence and innovation in non-formal science education.

The Centre has thus far been successful in its effort in achieving its objectives. However, with rapid developments in science communication channels, the Centre has reviewed and re-defined its strategic direction and develop a new vision. The new vision is:

“TO BE A WORLD CLASS SCIENCE AND TECHNOLOGY CENTRE”

The new mission statement is:

“To Promote Interest, Learning and Creativity in Science and Technology through Imaginative and Enjoyable Experience and Contribute to the Nation's Development of its Human Resource.”

In order to fulfil its mission objectives, the Science Centre runs five different categories of activities, namely:
Science Exhibition Programmes Science Enrichment Programmes Science Publication Programmes Science Promotional Programmes OMNI-Planetarium Programmes

Annually, these activities attract about a million visitors, 70% of whom are students. The Centre is acknowledged to be among the top ten science centres in the world.

Science Exhibition Programmes

Stimulating Exhibitions are the main instrument used by the Science Centre for the effective communication of science to visitors, both local and foreign. The themes of exhibitions are generally pertinent to the educational, economic, social or technological developments in Singapore. There are more than seven, 500 sq m exhibition space devoted to the exploration of various topics in science and technology. Currently, the Centre houses more than 700 exhibits, with each exhibit being an incubator of scientific knowledge.

Almost all the exhibition themes in the various galleries are related to the science syllabi of the schools and the exhibits serve as excellent materials for complementing science teaching in primary and secondary schools and junior colleges. The exhibits are also visually aesthetic and inviting for visitors of all ages. In designing and fabricating the exhibits, a delicate balance is struck between the educational aspect and entertainment value of the display—this is to capture the visitor's attention and to hold his interest long enough for him to explore and understand what the exhibits are trying to convey. With interactive exhibits to touch, see and hear, students would have a better understanding of the scientific principles involved and, at the same time, appreciate the impact of scientific and technological advances on their lives.

Science Enrichment Programmes

The Singapore Science Centre runs a series of science enrichment programmes to complement science teaching and learning in schools. Each programme has been specially developed to provide students some thought-provoking activities that encourage them to investigate further. Special emphasis on the hands-on experiments aims to captivate their imagination while illuminating essential scientific concepts and methods.

Annually, the Science Centre offers 1,700 enrichment programmes for more than 120,000 students. These enrichment programmes, which include laboratory courses, lecture demonstrations, science talks, gallery teachings, mathematical problem solving activities, observatory sessions and film shows, are conducted at the Science Centre during the school terms. Special arrangements can also be conducted during the weekends and vacations. Unique facilities provided by the Science Centre such as the Ecogarden, the Observatory, the Brain Station, the Primary Science Room and the Biotechnology Laboratory further enhance its education programmes.

Science Publication Programmes

Publications such as the Singapore Scientist and natural history guide books continued to play an integral part in the Centre's efforts of promoting and disseminating knowledge of science and technology.

(i) Singapore Scientist

Acclaimed as Singapore's best science magazine, the Singapore Scientist is widely read by teachers, students and members of the public who need information on the development in science and technology. It also serves to update readers on the Centre's activities. There is also a special pull-out section for students incorporating experiments, quizzes and unique features to supplement their science lessons. The Singapore Scientist enjoys a circulation of 25,000 copies per issue and an estimated readership of more than 120,000.

(ii) Guide Books on Natural History

Many a teacher have been embarrassed or perhaps nonplussed by students who expect them to identify organisms. These may be common plants and animals, none the less, the teachers may not be able to recognise them. The publication of the guide book series is in response to the paucity of educational materials on local flora and fauna. These guide books are approximately 160 pages in length and contain a wealth of information accompanied by many colourful photographs. They come in a
compact, pocket-sized format and are intended for a very wide readership, from the serious-minded science teachers and student to the casual nature lovers. A total of 30 titles had been published. More than 500,000 copies were printed and sold.

Science Promotion Programmes

The Science Centre organises mass-based activities through its promotional programmes which aim at encouraging participants to channel their creative energies and innovative skills into more productive pursuits in line with national aspirations. Some of the promotional programmes are described below:

(i) Singapore Youth Science Festival

First introduced in 1978, the Singapore Youth Science Festival (previous known as the Singapore Youth Science Fortnight) is an annual event jointly organised by the Singapore Science Centre and the Science Teachers Association of Singapore and sponsored by the Shell Companies in Singapore. The various activities of the Festival are geared towards conveying the message that there is more to science than just rote learning. Over 100,000 students now participate in the Singapore Youth Science Festival each year. A Science Teachers' Seminar is also organised as part of the Festival for science educators in Singapore. The Seminar aims to inspire teachers with some novel programmes in science teaching and learning, as well as to motivate them to try out different teaching strategies in the classroom. It also allows educators of youths to exchange views and experiences in science education.

(ii) primary Science Club and Activity Badge Scheme

The Primary Science Badge Scheme is jointly managed by the Singapore Science Centre, the Science Teachers Association of Singapore, the Singapore Association for the Advancement of Science and the Singapore National Academy of Science. It is supported by the Ministry of Education. The main objective is to encourage students in primary schools to develop initiative and creativity by carrying out self-directed activities in various areas of science. Under the scheme, a student may earn badges in many disciplines. More than 50,000 badges are awarded every year. Selected projects undertaken by badge recipients would be displayed at the annual badge presentation ceremony.

(iii) The Virtual Science Centre

The Virtual Science Centre (VSC) is a computer-based project which makes use of Internet technology. It aims to facilitate on-line interaction and to encourage information exchange and resource sharing among students, teachers, schools and public users. The VSC project enables the Singapore Science Centre to expand beyond its physical boundaries into cyberspace. It provides the Science Centre with a complementary platform to further enhance its existing programmes. With the support of the National Science and Technology Board and the National Computer Board, the following facilities have been developed:

a) a science education server to store and update science education information and resources for access by schools and public users locally and globally; and

b) public access terminals to allow visitors to acquire additional science knowledge over and above the existing exhibits at the Singapore Science Centre.

Currently, both new and archived information on programmes and activities of the Singapore Science Centre and its Omni-Theatre can be accessed at http://www.sci-ctr.edu.sg/. The Science Centre is working with professionals as well as institutions to explore new ways of presenting information on science, research and technology and promoting science awareness and enthusiasm within the framework of VSC. Students, teachers, science clubs and associations, scientific and professional organisations, publishers, and other science-related specialists would be invited to participate.

OMNI-Planetarium Programmes

OMNIMAX programmes use a film frame 10 times larger than the conventional 35mm film and a hemispheric screen which 'wraps' the audience at the centre to give them a remarkable sense of involvement. When the show begins, the audience would be engulfed by the immense size and three dimensional quality of the undistorted picture. They lose perception of time and space and forget that
they are in a theatre. They can feel the motion and it is like taking a trip in a time machine. It is an expressive, engrossing and ever startling experience, both educational and exciting.

The planetarium programme is produced by a highly sophisticated projection system which is able to provide an accurate and realistic projection of stars and other celestial objects across a five-storey high, 23m wide hemispheric screen to create an illusion of the night sky or space. The projection system consists of an array of more than 100 slide and special effects projectors, including the starbase projector, which has a staggering 10,164 lenses, one for each of the stars it projects. It can present the sky as seen from any planet in the Solar System at any time of the year. You can even travel in time to see the sky our ancestors saw thousands of years ago, or the skies as they will appear in the future.