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A CONCEPTUAL FRAMEWORK FOR EFFECTIVE STRATEGIES FOR INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION: A CASE STUDY OF MAURITIUS

A Dissertation Presented

by

PAPAYAH GURUVADOO

Submitted to the Graduate School of the University of Massachusetts Amherst in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

May 2003

School of Education
A CONCEPTUAL FRAMEWORK FOR EFFECTIVE STRATEGIES FOR INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION: A CASE STUDY OF MAURITIUS

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Approved as to style and content by:

Robert J. Miltz, Chair

David R. Evans, Member

Beverly P. Woolf, Member

Andrew Effrat, Dean
School of Education
DEDICATION

I dedicate this work to my father Rajanah and late mother Chilka for their passion for education, and love and confidence in me, and my family for their support and encouragement.
ACKNOWLEDGEMENTS

I am most indebted to Professor Emeritus Robert J. Miltz, the Chair of my Dissertation Committee, for his intensive advice, constructive criticism, scholarly attitude, and immense help that he has extended to me during the years that I spent at the Center for International Education, Department of Educational Program for Administration and Leadership.

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ABSTRACT

A CONCEPTUAL FRAMEWORK FOR EFFECTIVE STRATEGIES FOR INFORMATION AND COMMUNICATION TECHNOLOGIES IN EDUCATION: A CASE STUDY OF MAURITIUS

MAY 2003

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Directed by: Professor Robert J. Miltz

This dissertation focuses on three country case studies: Singapore, United Kingdom, and United States, with occasional compelling examples from elsewhere. The cases are analyzed and synthesized into a rich and comprehensive conceptual framework with contextual factors and a set of metrics that can be used as a lens to assess a country's readiness and needs in terms of Information and Computer Technology education. The lens is applied directly to the case study of Mauritius as a test-bed, and yields the basis of a consensual strategic technology plan for education. Finally, the lens is tweaked to examine possible technology transfer to developing countries, in particular, to Africa.

Further, this study develops the human capacity component of the United Nations Development Program - Markle Foundation's conceptual framework of the components of the development dynamic model, into a model for ICT education, thus providing an integrated conceptual model for ICT education, and ICT industry and/or development.
By scanning the environment against the backdrop of the Information Revolution, the author reaped a body of practices and refined them into a set of best practices in teaching, learning, educational administration, school restructure, teacher training, infrastructure, contents, research and evaluation, school linkages with parents, community, business, and other stakeholders, strategic compact, leadership, funding, and sustainability.

The results of the study impact e-learning and virtual institutions, the digital child, information literacy, computer fluency and new skills for productivity and creativity in the emerging knowledge-based society, and the digital divide.

The implications of the dissertation are the provision of a clear guide to effective planning for ICT education for a broad range of countries and ICT transfer to developing countries. The study also explores some pathways in the search for a new social order where the digital capital of the ICT-developed countries could extend the digital dividends to minimize the digital divide within and between countries. It fills a gap in an increasingly important area of knowledge in a confused and turbulent environment.

It will be useful to most governments, which have recently expressed some ambitious strategies for stimulating and supporting the use of ICT in education.
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CHAPTER 1

INTRODUCTION

Chapter 1 introduces the theme of Information and Computer Technologies (ICTs) in Education against the backdrop of the Information Revolution. The problem and the purpose of the study are stated; the questions asked and the rationale explained. The eventual aim is to construct a conceptual framework to support the main objective and to integrate it into a super model for ICT Education and ICT development. Then the section on clarifications and delimitations discusses the assumptions, constraints and the problem generalization. Finally, a chapter outline closes the Chapter.

Information Revolution

We have been through the Agrarian, Industrial and now the Information or conservatively, Post-industrial Revolution (Toffler, 1980). In the 18th century, the Industrial Revolution transformed the agricultural society of muscle power to an industrial society of energy power where steam engines revolutionized socio-economic activities of individuals, business and government resulting in unprecedented wealth, prosperity and easy life style. Progress was uneven; problems and hardship accompanied the process of realizing further prosperity; everyone carried out drastic reform of the social structure; the educational system underwent drastic reforms to provide mass literacy in the three R’s of Reading, wRiting and aRithmetic. The impact rippled around the globe creating the industrialized countries, the newly industrialized countries and the developing countries along the spectrum of development according, among other things,
to the degree of adoption and success of the technology. Now, the Information Revolution calls for a new order. Certainly, the changes are not linear but multidimensional.

We can understand previous revolutions when we are well out of them. When we are in the midst of a revolution, it is hard to see and understand all that is going on. The Information Revolution is not like the previous ones because it is actually taking place at an incredible speed over space and time, pulling in people across cultures, faiths, nationalities and economies all over the world. Such an unprecedented dimension of the phenomenon is practically hard to encompass, comprehend, harness and to develop effective strategies to cope with it.

On the other hand, we need some sense of direction where we are heading, to be prepared for the changes and to take advantage of what the digital world has to offer as we surge forward. We have to plan the ‘ephemeral’ and allocate competing resources in education and training, especially for children and young adults for the survival of humankind, and for adults to undertake the present.

At best, we can take a series of snapshots over time to perceive some trends or several snapshots of the ‘hot’ things happening at the same time period and then weave through the main nodes to grasp the essentials from our perspectives of Information and Computer Technology (ICT) Education, as explained in the section of the problem statement. Also, we need to take a few steps back to take stock of the panoramic pictures to understand the big picture.
Background

'Technology' is often associated with inventions and machines or viewed as applied science or, more recently, with computers and telecommunications. Educational Technology is defined as a combination of the processes and tools involved in addressing educational needs and problems, with emphasis on applying the most current tools: computers and their related technologies (Roblyer, 2000). Information Technology is the convergence of computers and communications, hence the European term Information and Communication Technology (ICT), which, in its wake, defines new technologies and embraces others, like radio, television and the press. The digital media is the latest to join ICT, and all are collectively referred to as Information and Computer Technologies (ICTs). Strictly, I need a broad term that includes all activities which facilitate, by electronic means, the processing, transmission and display of information through the convergence of computers and telecommunications (IT) and the media (all together as ICT), and emergent technologies (all together as ICTs). Their applications in education are fashionably referred to as e-learning. Although there has been an evolution in usage, the following terms are used here interchangeably to admit different countries’ status and usage, unless otherwise stated: IT (in the East and initially by UNESCO), ICT (in Europe), Educational Technology (the generic term) or simply and beautifully Technology (in the United States). The powerful multimedia incorporates data, sound and video. They appeal to our senses as never before. Furthermore, hypermedia affects our perception of reality, leading to virtual reality. The World Wide Web (WWW), which is a repository for knowledge and learning that are available to all, offers multimedia over the Internet, the buzzword, which is a global
network of computers that connects people who e-mail their families, friends and colleagues, chat with people – some of whom they have never heard of before and still remain anonymous. They exchange pictures, surf the Internet and search for information, documents, books, etc., e-shop for bargains after having compared various competitors’ prices and goods, belong to virtual societies through special interest groups (SIG), and subscribe through listservs to e-magazines, e-newsletters, etc. Information is the nucleus of today’s interconnected economy, cultures, societies and governance. This is about people in cyber culture (hungryminds.com, April 12, 2000) who want to use computers to communicate one-to-one or one-to-many on the local, regional and global levels, thus forming a wired society (Negroponte, 1995). More recently, a wireless society was developed via microwave dishes and satellites with mobile phones, personal digital assistants (PDAs) or palmtops using Wireless Applications Protocol, and notebooks that connect to desktops, home appliances, and vehicles, using Blue Tooth Technology (Hansmann, U., Merk, L., Nicklous, M. S., & Stober, T., 2001). There is an exponential growth in the number of users of Internet worldwide. The growth of e-business has been phenomenal even if, subsequently, many dot-com companies folded due to weak business models but not to the robust technology. “Twenty first century computing will be pervasive or ubiquitous – everywhere at any time” noted (Hansmann, U., Merk, L., Nicklous, M. S., & Stober, T., 2001, p.1). Lou Gerstner, IBM Chairman and CEO sees the future as “… a billion people interacting with a million e-businesses with a trillion intelligent devices interconnected …” (Hansman, U., Merk, L., Nicklous, M. S., & Stober, T., 2001, p.1). Smart objects will form part of our daily life and holds the promise of easier lifestyles. The notion of work, leisure and school as separate
entities will blur (Toffler, 1974, 1984). Like it or not, ICT will impact on all of us. Hopefully, ICT will bring people together to achieve, as Joël De Rosnay called it in the Global Brain “a global consciousness” (esiweb2.cite-science.fr, May 29, 2002). Those of us who can harness the enabling technology will find it rewarding.

**Information and Computer Technology Education**

It is assumed that technology is a creative process to solve problems; it enables people to have some control over nature. IT is an enabling technology! As technology evolves, so must education, and in particular, Information and Computer Technologies (ICT) in teaching and learning.

Education can benefit from ICT, which can globally provide customizable and intelligent multimedia flexibly with asynchronous access and delivery. Many e-classrooms, laboratories or studios have television, video equipment, cameras and computers that are connected to the local area network and to the Internet. Teaching materials are no longer limited to books within national borders; they are distributed around many places in the world and are available online, often free. Remote students can work collaboratively on projects. The exchange of information must be directed to meet the needs of the new environment. “What to teach”, “how to teach” and “when to teach” form part of a pedagogy in this new triad relationship of teacher-computer-student. The teacher’s role is changing from a fount of knowledge to a facilitator of students’ learning experiences. Learning becomes student-oriented and equips the students for lifelong education because they need to continually adapt to changes, as they will change jobs a few times in their productive lives. Unfortunately, most
computer education teachers are not ready for the change. More teachers need to be trained and retrained differently than in the past as the technology is in a state of fast change.

Computers and peripherals are still expensive although prices have come down a lot due to mass production and wide market base. Students-to-computer ratio is still high although in some schools in industrialized countries this ratio is 1:1. Some schools have limited Internet connections because of high cost of telecommunication rates. Equipment becomes outdated in a short life cycle of five years for home use and of two to three years for school use. The park of computers has to be continually maintained and renewed, incurring expenditures that many schools cannot afford. There is a tension between the desired investments in computer education and other priorities in education and elsewhere. Affordability is a serious issue. Developing countries have basic priorities and cannot afford this type of education yet it is a pole vault for development. The digital divide exists in each country. This raises issues of access, equity and gender.

Students live in an era of high entertainment that is far more interesting, from their viewpoint, than traditional textbooks or readings. They appreciate and remember in great detail MTV commercials or video music clips even if they have seen them once. They spend hours daily watching television and or playing digital games or surfing the Internet for their esoteric pursuits. The traditional school is different from the entertainment environment and does not interest many students. With computers and new curricula using ICT at school, the challenge is in the action. Consequently, many students find the modern class as an interesting extension of their lives. Alas, the
traditional form of assessment has not changed significantly. Issues of performance testing, comparability, accountability, etc., still fuel the debate.

The gap between technology and technology literacy is widening. ICT is changing at an exponential rate and most of us perceive an urgent need to educate the children, youth and adults to become technology literate, computer literate (‘computerate’), ICT literate or information literate. Technology education emphasizes the process of learning, i.e., learning to learn rather than learning the end-products, and attempts to link the affective, cognitive and psychomotor skills harmoniously through technological activities, software, or e-simulations that enhance high order problem solving skills through Piaget’s constructivism (Elkind, 1976; Papert, 1980; Piaget, 1926; Waite-Stupiansky, 1997).

Technology education has been implemented in many countries over the world in different ways depending on the context, the perceived societal or individual needs). However, as Technology Education is relatively new in the school curriculum, there are many unanswered questions about its implementation. Since 2000, UNESCO, World Bank and many private think tanks have been interested in ICT education and its strategic implementation.

The development and implementation of ICT is a concern for all countries. The developed countries have implemented ICT. Yet they are still struggling with problems of access, digital divide, and human resource development. Some of the challenges are financial: to renew and increase the park of computers in schools and universities. Other challenges are technological: to harness the new technologies that are developed at a fast rate. Still other challenges are human: to create interesting contents online and find
effective methodologies for ICT. The Newly Industrialized Countries (NICs), have less resource but need not “re-invent the wheel.” NICs, through partnership and technology transfer, with the West and among themselves, can educate, train and retrain their people who already have a relatively high level of education, to become ICT literate and active partners in the production of software and in the consumption of information.

**Problem Statement**

ICT has a great potential for education because it can increase the learning experience of learners. However, restructuring schools to make them more relevant and more interesting and, in the long run, less costly, and effectively deliver instruction through distance education and open learning for formal and non-formal education raises many concerns:

Each set of stakeholders of ICT education has its own agenda. Students, parents, business, politicians, the state and other stakeholders are attracted to ICT that carries a sense of novelty, power and appeal. ICT applications challenge students; parents support ICT education for their own empowerment and for their children’s employability; business needs trained manpower as there is a shortage of ICT skills, and politicians are too eager to serve and sometimes for their own interest. When different interests converge to goal coherence it is easier to manage the implementation of ICT education successfully.

Often, ICT is introduced without proper planning because, in the wake of wide demands for ICT, politicians rush through to capitalize on popular votes and often put the cart before the horse. This raises many questions without answers about technology
readiness, infrastructure, affordability, training and procurement. Often the capital and recurrent expenditures, and training are grossly underestimated. Many initiatives and projects are unscalable (inextensible) and unsustainable.

Insufficient funds, traditional pedagogy, lack of trained teachers, scarce curriculum materials, restricted number of computers, and lack of access to the Internet have often crippled controllable pilot projects, which cannot be scaled up nationwide. This can create the digital divide between students of different economic classes, gender, and generations in the community in different geographical regions within the same state or country, in north-north, north-south and south-south regions of the world.

Often times, private individuals and non-governmental organizations start ICT initiatives in education are started by local private individuals. These efforts remain limited in scope until the government decides that it is its responsibility to provide equitable access to ICT education. We need a strong leadership and high-powered representative task forces/committees to rally the people, mobilize resources, enter into strategic alliances with the private sector and international partners for continuous investment and technology transfer, change laws for deregulation of telecommunications, and streamline processes, Weak commitment and lip service are prescriptions for disaster. Lack of ownership of ICT projects has resulted in mitigated success. All stakeholders should collaborate.

Putting huge amount of resources into new ICT education invariably generates resistance and conflict, especially so where basic education for all is not reached. By nature, people, including teachers, resist change that impacts their learning, preparation
and responsibility, and undoes their traditional teaching and status. Change is to be managed successfully otherwise it brings chaos.

ICT is expected to increase the learning experience of the learners. Yet the triad interactivity of teacher, students and computers is still not well understood and calls for more research. The curriculum and pedagogy need continual evaluation and update.

The new economy needs more knowledgeable workers. An acute shortage of ICT workers exists from teachers, office knowledge workers, and administrators to top managers. The complexity of modern life calls for a change in education. Skills that are taught should be adaptable and employable. People require lifelong education and training through both formal and non-formal methods by distance education and open learning. The costs of education keep rising. ICT education is expected to play an important part in the restructuring process but sometimes is absent from a clear development strategy.

Hence, there are numerous problems facing the implementation of ICT at schools. Strategic planning is required. Admittedly, ICT is relatively new but there is a body of knowledge accumulated during the experimental ICT teaching period of the last two decades. This should be disseminated to all practitioners. Further research into the learning process and the strategic deployment of ICT in education is needed.

Purpose of the Study

The purpose of this dissertation is to produce a strategic plan for ICT education, with Mauritius as a case study. This can be achieved by first reviewing the best practices and the state of the art of ICT education. Secondly, we can abstract from some cases
studies and ICT education development, a framework with a set of indicators as metrics for ICT education that can serve as a lens to assess the needs of a country and develop a strategic plan for ICT education. The proposed framework also investigates the issues involved with ICT for learning and teaching, the effective strategies to introduce or enhance ICT education, and the restructure of learning environments, with particular reference to secondary schools. Finally, the lens is used to examine how to transfer ICT education to some developing countries, in particular, Africa – the poorest continent.

The above can be expressed in terms of research questions that guide this study.

Research Questions

Primary and implementing questions are:

1. What are important current issues in education, and how can ICT address them? In particular, how can we use ICT to restructure the educational environment to maximize educational benefits?

2. What is an appropriate framework to analyze and make a needs-assessment of ICT education? Can we develop a lens to be used to plan ICT for other countries?

3. What is an appropriate strategic ICT education plan for Mauritius? What have been the main issues in education in Mauritius? What is the needs-assessment in terms of ICT education?

4. How could the above model be adapted in a technology transfer to developing countries?
In order to answer the above research questions the study will proceed in three main steps. First, from a theoretical approach, the study will explore the past, present and future learning and teaching within technological environments, highlighting effective strategies to restructure these environments to promote quality yet cost-effective education (Chapter 2). The research methodology will be explained (Chapter 3). Secondly, the study will scan the environment for strategic technology plans in education that have been implemented in three specific countries, namely, Singapore (NIC), the United Kingdom, and the United States, which have developed ICT education to a large measure, and within a broader context of notable experiences in other countries (Chapter 4). The information will be synthesized to a body of knowledge that will constitute a conceptual framework, which will be used as a lens to help examine a country’s readiness and need assessment to develop a strategic plan to realize an effective educational technology system that promotes teaching and learning (Chapter 5). Thirdly, the model will be applied to Mauritius as a test-bed in an ICT transfer model to other developing or newly industrialized countries (Chapter 6). Finally, the conclusion will include the adaptation of the conceptual model to explore some pathways to the cooperation for technology transfer and development of ICTs to developing countries. This study will fill in a gap of knowledge by providing a rich and comprehensive framework with a set of metrics to guide the readiness and needs assessment and strategic technology planning, and will also contribute to the scarce knowledge about the new educational technology development that is feasible in some developing countries (Chapter 7).
Computers have been around for about half a century. Computer technology has imposed itself as an enabling technology in business, industry and government. It is natural that it has affected education also. With the advent of affordable, powerful and user-friendly personal computers, the potential use of computers in education is a reality. Furthermore, computer-networks can link up classrooms, schools, libraries, within institutions, regions, countries, and the world. The Internet spans the world into a global village. This reachability factor makes the Internet a potentially powerful delivery medium. Naturally, education has an important place in this cyber world to create the learning and knowledge society. E-Learning is about using ICT to provide rich learning opportunities to “all” children and adults, and not about technologies.

As regionalization and globalization of economic and trade activities take place, the world becomes more interdependent. There is a need to adopt and adapt educational technological systems that have been developed in the West in order to leapfrog to the frontier to promote e-business, e-economy, and the knowledge society. Newly industrialized countries (NICs) do not have to “re-invent the wheel” of the developed countries but they have the resources to repackage the systems for local consumption. Mauritius, has recently become a NIC. Both the developed countries and NICs have realized that they need to take on-board the developing countries in order to bridge the gap between the rich and the poor which threatens freedom, peace and democracy, and the world economy. This is a win-win situation. But the challenge is that the developing countries have little infrastructure and could not attract investment for the expensive
ICT and, still less, for learning and teaching technologies, in relation to their urgent needs for food, clothing, habitat, etc.

However, technology offers wider access and more contents at cheaper costs. In India, China and other emerging economies, affordable technologies make it possible to reach the far-off villages by broadcasting, even from “studio” tents costing about $10,000 through satellites that beam down information and knowledge for education and training.

This research will contribute to the scarce knowledge about needs analysis and strategic planning for implementation of ICT in teaching and learning. The third part of the study will sketch some pathways for some developing countries to the new educational technology. It will be useful for donor institutions, like UNESCO, World Bank, ASEAN Bank, African Development Bank, Arab Bank, Commonwealth Fund for Technical Assistance in England, and a host of non-profit foundations.

**Conceptual Model**

A conceptual framework is developed from the analysis and synthesis of available international literature and of experiences in implementing ICT for teaching and learning in industrialized and newly industrialized countries and in the author’s own practice in Mauritius. It serves as a lens to make an ICT readiness and needs-assessment for planning to implement e-learning. This model fits into the human capacity component of United Nations Development Program’s Components of the Development Dynamic Model (undp.org, February 13, 2002) to form a unified model for ICT development in a broader context. The model is applied to Mauritius to assess its
validity, reliability and scalability. Also, it is adapted to deal with a possible technology transfer to developing countries, in particular, to Africa.

Clarifications and Delimitations

Assumptions

It is assumed that the enabling power of ICT and other related innovative technologies will make them attractive and useful worldwide. It will affect traditional lifestyles as other major technologies and revolutions have done in the past. The changes are on-going and will intensify as we accelerate, like it or not, into the future.

With the trends in technology and, according to Moore’s law, which states that the computing power doubles as its cost halves every eighteen months (Capron, 1998), there will be wider adoption of ICT and ICT-based education as computers become more capable, affordable and user-friendly. Eventually, they will become commonplace items like pens and pencils (Papert, 1983) in the school environment and elsewhere.

ICT will contribute to restructuring schools and society as they grapple with keeping up with new technologies for more effective management, access, content delivery, teaching and learning styles. The school as we know it may not survive. However, we will still need teachers, although possibly fewer. They will be empowered to facilitate a student-centered rather than the traditional teacher-centered pedagogy where the teacher is the fount of knowledge.
Constraints

Quick fixes may be cheap interventions in the short-term but a reactive strategy creates unbounded problems. A systems approach that is fairly robust to change is needed. The school environment is new to systems thinking.

Traditional strategic planning is meant for long-term planning but ICT brings fast changes. The nature of strategic planning is changing to deal with the present volatile order of things. The classical approach is modified to consider medium term as incremental steps that require flexibility and frequent review rather than traditional long-term approach to strategic planning. In times of fast changes in technology, knowledge, skills and funding, scenario analysis, scoreboard and dartboard methods are sometime used instead of the classical approach.

Financing capital and recurrent high expenditure in ICT investment is precarious even in industrialized and newly industrialized countries. This is a threat to sustainability and extensibility of ICT education projects or programs. Rich countries place ICT at the center of the educational experience while middle-income countries position ICT at the periphery of the continuum. The challenge is where poor countries lie on the continuum.

Attention should be paid to the digital divide in terms of class and gender in schools and the community, with respect to access and educational experience. There is resistance to change and the management of change is a central issue. There is a shortage of trained manpower in ICT and a great demand for ICT teachers and trainers. Alternative models of training need to be considered. Open and distance learning systems seem feasible.
Problems of Generalization

The data collected for the purpose of this dissertation could only relate to a short time in this framework. Continual surveillance and update are needed throughout the systems cycles.

The findings are limited in scope due to the scale of the phenomenon. The conclusions may be local at best, although there are certain aspects that are of a general nature and are useful to consider for technological transfer.

The strategies of promoting or enhancing computer education are bounded in space and time, cultures, languages, societies, politics and economies. The tensions referred to earlier will disrupt the adoption of the recommendations to some extent.

Preview of this Dissertation

Chapter 1 introduces the main theme against the background of the Information revolution, discusses the problem statement, the purpose of the study, the research questions, the clarifications and delimitations, and the conceptual framework within which the study is conducted. Chapter 2 is a review of the previous literature on the relevant topics that this study encompasses. Chapter 3 describes the methodology, the structure of the study and data collection. Chapter 4 surveys relevant technologies, strategies and implementation plans in three major countries: Singapore, United Kingdom and United States. Chapter 5 describes the analysis and synthesis of the case studies in chapter 4 and empirical studies elsewhere in the world, and the development of a lens to analyze ICT in terms of a conceptual framework with a set of metrics about readiness and needs assessment for strategic technology planning. Chapter 6 describes
the needs analysis and applies the lens from Chapter 5 to develop a strategic plan for Computer Education in Mauritius as a test bed for the lens. Finally, Chapter 7 summarizes the study, reviews the conceptual model, and the questions and answers, discusses the impact and implications of the research, makes some recommendations and suggests future research. In building an equitable global village, some possible avenues for cooperation are explored in an attempt to adapt the conceptual framework to deal with ICT transfer to developing countries. The chapter concludes with optimism and caution.
CHAPTER 2

LITERATURE REVIEW

This chapter contains the main theme of Computer and Information Technologies in education against the background of the Information Revolution, and reviews the theoretical underpinnings of the components of a possible conceptual framework for ICT education.

The review of literature provides a conceptual platform. The questions that were raised and the purpose of the study as mentioned in Chapter 1, drove the literature search to better understand the issues, the design, conduct and report of the study.

It is convenient to look at the linkages of ICT, its applications in education and other themes in the context of the Information Revolution. The advent of personal computers in the early eighties, and the initial public use of the Internet and the World Wide Web in 1994-95, have impacted the global consciousness as useful tools in education and in other spheres of life.

The background to this study on some effective strategies to enable Information and Computer Technology (ICT) education at schools covers a broad range of topics, including the Information Revolution and the consequent turbulence, ICTs, historical development of computers in education, the current teaching and learning technology, the information and technology infrastructure, renewal issues, access issues and the digital divide, teacher training, restructuring schools with technology, anchor in the community and the private sector, research and evaluation, and dissemination of knowledge, world of work, and strategic planning.
Themes of the Information Revolution

Sometime during the second half of the 20th century, Western Society evolved from an industrial to a post-industrial and an Information Society. It is characterized by a service industry that depends on information as its life-blood; an information explosion due to computers that can process high volume of data into information in a fast, timely and accurate fashion; the use of knowledge which is information that human beings process to form insights and judgments; and by the Internet, which amongst other things, connects people to communicate.

"Information is the raw material for the fastest growing sector of the economy – the knowledge industry," said Tom Stonier (1983, p. 8). Also, ICT has connected the world into a global economy with just-in-time distributed production, just-in-time learning, and almost free flow of financial and human capital. This accelerated turbulence has impacted education and calls for restructuring the school and its environment.

In trying to understand an on-going Information Revolution, we need to keep in mind the big picture and locate the foci of activities with respect to the linkages to ICT. From international forums, Amidon traced three main themes of access, empowerment and governance, and the generic issues of a knowledge society, namely: fostering the requisite mindset, allocating and mobilizing resources, bridging the digital divide and addressing the issues of gender (entovation.com, April 1, 2001). The priorities were identified in six theme areas: education, politics, technology, culture, economy, and the environment. There were three additional forums on "Youth for a Knowledge Society", "Woman’s Forum on Gender Empowerment and Effective Participation in
Goverance,” and “Media Forum about Convergence and Technology, Cultural Diversity and Identity, Democracy and Media Freedom, Access and Empowerment, Ownership and Control of the Media and Education” (globalknowledge.org, March 12, 2002).

What is the relation between the different economies and ICT level? The industrialized economies (OECD/G8)*, the newly industrialized countries (NICs) and some developing countries have in common an appropriate mix of the above-mentioned six factors that are related to ICT development. Rodriguez (2000, p. 11) stated, “developed economies have higher technological investment” and “the rich countries enjoy higher technological progress, and the level of GDP per capita is strongly associated with the level of ICTs.” In 2000, the International Telecommunication Union found that the Internet usage is linearly related to the gross national product (GNP), see graph in Appendix A. Again, Rodriguez (2000), Kahin and Nesson (1997), and Skolnikoff (1993) noted ICT diffusion rates may influence and be influenced by a nation’s legal, institutional and political environment. Central to such an enabling environment are civil liberties, including freedom of expression, transparency of institutions and protection of property rights. Finally, Rodriguez (2000, table 3) – see Appendix B - produced an index of technological progress (ITP), in terms of using ICT (personal computers, Internet hosts, fax machines, mobile phones and television) to process information. They ranked the top ten countries as members of OECD and the top twenty as still members of OECD countries and Hong Kong and Singapore

* OECD is the Organization for Economic Co-operation and Development; G8 is an organization of a group of the most industrialized and rich nations: Canada, France, Germany, Italy, Japan, United Kingdom, United States and Sweden.
(members of NICs) being in the 11th and 13th places. The bottom 10 economics are all in the sub-Saharan Africa. The highest ranked sub-Saharan African economy is Mauritius in the 46th place (Appendix B). The correlation between the ITP and ITP-core or when ICT is restricted to personal computers and the Internet is 0.94, and when the two items: radios and newspapers are included (ITP-broad), the correlation between the ITP and ITP-broad (extended) is 0.99, see Rodriguez (2000, p.15). Hence, it does not matter much, which ITP index is used since ITP-core and ITP-broad are highly correlated with ITP as defined above.

For a long time the linkage between knowledge and progress was made. An emergent economic order is based upon the flow of intellectual capital. Amidon and Macnamara defined the Knowledge Economy as being characterized by the ability to focus upon and manage knowledge – individual and collective – more explicitly. At the heart of the current transformation is the human being within whom knowledge resides. Again, Amidon and Macnamara stated that a sustainable future for the knowledge society hinges on people’s ability to innovate, i.e., to create knowledge, convert it into viable products and services and apply it for the profitable growth of an enterprise, the vitality of a nation’s economy and the advancement of society (entovation.com, April 1, 2001).

Exploring a Theoretical Framework for ICT Education

The United Nations Development Program (UNDP) published Accenture and Markle Foundation’s study on ICT Strategic Deployment, 2001, which proposed a sound model for ICT industry in the form of the Components of the Development
**Dynamic Model** (undp.org, February 13, 2001). Briefly, the model describes a strategic compact around five core components of human capacity, policy, content applications, enterprise and infrastructure. In this study, the author develops the strategic compact over the sub-components of the human capacity with respect to ICT education. An onion ring model integrates the school, parents, community, and private sector and NGO; research and evaluation; exchange, consensus and dissemination through universities and teacher training institutions under the umbrella of the Ministry or Department of Education. A layer can communicate with any layer and outside the system. At the core of the students' learning experience lies the pedagogy and curriculum within the triangle of students, teachers and ICT. The new technology-oriented school environment is best served by high quality educational software, hardware, and connections to the Internet, universal access to the technology, and trained teachers in ICT who feel comfortable to teach ICT as a subject or integrate ICT into the curriculum. ICT virtually opens up the school to the community and to others: parents can extend the school to home; adult learners can pursue lifelong education; and business oversees the relevance of the school curriculum. The involvement of the business community in school matters may be a necessary “evil” but it does hold the school accountable for its sustainability. Although schools can be decentralized yet tighter control through ICT can be achieved at the headquarters, yielding a more effective management of resources.

Together, the studies constitute a unified conceptual model for ICT development and ICT education. Finally, from the analysis and synthesis of the case studies, the
author developed a framework that could be used as a lens to examine other countries’ readiness and needs for ICT education, and applied it to Mauritius as a case study.

ICT Education Problems

The main problems of ICT education are access, teacher training and curriculum. Low student: computer ratios and broadband Internet connection facilitate access. Lack of access is expressed in the digital divide, which affects class, gender, age, intellectual ability and physically challenged learners. Teachers are being trained in ICT as a subject or integrating ICT into teaching across the curriculum. However, many teachers do not feel confident to integrate ICT across the curriculum. Teachers’ role is changing from a fountain to a facilitator of knowledge and the pedagogy is moving from teacher-centered to student-centered. Also, the curricula are changing to reflect the needs of modern society.

In fact, there are many problems with using IT in schools. There are five main factors that restrict progress in wide adoption of Computer Education: capital investment in hardware and courseware and some other software, organization’s reward structures, resistance of student population, feeling of apathy about new technology, and lack of proven effectiveness. Coburn, Kelman, Robert, Synder, Watt, and Weiner (1982) exposed the conflicting issues in software utilization, and Schacfermyer (1990) commented about the poor quality and suitability of educational software.

Restricted free access to computer laboratories resulted in underutilization of the computer systems. This was due to great demand, shutdown of schools after working hours, lack of delegation to others to take charge because of no incentives, and lack of

However, Streible (1986) analyzed the impact of computers on education and found out that computers are rapidly being incorporated in schools. Coburn (1982) reported some good use of computers by teachers, and that computers increased learning. To do well in class, computers should be second nature to both teachers and students. Computers have been used in learning and teaching across many subjects including science and mathematics. However, according to Sohawon (1987), Boolaky (1989), Choolun (1998), Mannick (1998) and Thyartan (1999), teaching about computers instead of teaching with computers, and learning mathematics and science, have received more attention because traditionally teachers of mathematics and science have been good at using them.

For schools to fulfill their potential in ICT and for the success of computer education, it has been suggested that schools should carefully consider how they would deploy their technological resources for the maximum benefit of teachers, parents and the wider community. Schools should take up the challenge of becoming economically accountable for their resources with respect to students access to computers and teacher support.
Infrastructure

Initially, computers were housed in a computer laboratory. Then computers were placed in classrooms. Some computers were connected to the Internet. Later the computers were networked within the school and connected to the Internet. Networking facilitates the sharing of resources, like printers, files, programs, video disks, etc., and later to connect to the Internet for accessing external resources, like emails, chats, special interest groups, publications or databases. The ratios of students:teacher (class-size), computers:school, computers:class, internet connections:school, and internet connections:class are some indicators of the facilities of ICT available for teaching and learning.

Computing technology has evolved at a tremendous rate. According to Moore’s Law, computing power doubles and cost halves every eighteen months (Capron, 1998). Miniaturization leads to reduced size, forms and costs, and hence to portability and affordability. Desktops, laptops, notebooks, palmtops, and cellular phones are wired or wirelessly connected to the Internet. Pervasive computing devices provide mobility and connectivity. According to International Data Corporation, there would be 48 million non-PC devices accessing the Internet by 2001 and it predicted that about half of the web-enabled devices sold by 2002 would be non-PCs (Hansmann, Merk, Nicklous, & Stober, 2001). Mobile phones are rapidly becoming the preferred means of personal communication, creating the world’s largest consumer electronics industry. “There will be as many as 1.6 billion cell phone users worldwide by 2005,” according to Kalb and Springen (2000, p. 63).
Some of the emergent technologies, including the digital media, will be popular in the school environment. Already, electronic notebooks are becoming increasingly popular in higher education and high schools. Mobile phones and personal digital assistants (PDAs) can access the Internet and will soon find their way into education. The need for keyboarding will be superseded by handwriting pad and voice technology. Children will speak into these wireless machines that will respond with powerful multimedia of sound, video and data. Computers will really be powerful extension of the mind (Papert, 1980).

In sum, the computing paradigm is connectivity and integration. It ensures open, portable, integrated and connected systems with software architecture. The client-server model for accessing information is client-thin server-thick. Individual access for learners is made possible via asynchronous delivery (manic.cs.umass.edu, December 2, 2000) and for a group access via synchronous delivery to individual computers or videoconference. Wireless connectivity provides access anywhere and anytime – pervasive computing.

Equity: Access and the Digital Divide

In general, the provision of a few computers or Internet connections using modems to many students places unrealistic expectations. The computer is not a television set, which students watch but a machine to interact with. There are constraining effects of high student-to-computer ratio. The limited number of computers often times forces a selection panel of representatives: one from the Mathematics and one from the Science departments and one from the career advisor, to select a restricted
number of students based on certain criteria of high performance in mathematics and sciences. This favors high ability students and excludes others, including physically challenged learners who cannot access computer laboratories without ramps.

“A boys’ club attitude prevails in IT class causing a gender divide”, according to Coburn, Kelman, Robert, Synder, Watt, and Weiner (1982). There is also a social class differential access because the rich students, who can afford computers at home, continue to have access at school and do better.

The digital divide affects low-income households, including the many old people, as they do not afford home computers with Internet. For the middle income and above earners, the school is virtually extended into their homes and consequently their children do better at schools.

As a way of alleviating the problem in poor neighborhoods, computers with Internet are installed in community centers where the user can access information about jobs, government regulations and schoolwork.

Partnership: Parents, Community, Private Sector and the School

The Internet facilitates communications between remote schools, electronic libraries, communities, stakeholders, state and countries. It is about people who are virtually connected. Being partners in education, parents, teachers and the community are being connected to the school; they can learn and share the school resources as well as participate in the learning experience of children.

Datta and Kanter (ISTE, 1998) researched the exchange of paper documents, the number of phone calls between the schools and parents, the number of newsletters from
the schools, and the amount of homework that parents are asked to participate with their children. The results showed that ICT could facilitate communications between the two groups. Similarly, other partners with the schools, like mentors, school board members and business could benefit from the facilities. Besides, the whole community can use the school network server and the schools can train members of the community for a sustainable ICT program. And, the children can continue to work from home on their school projects beyond school hours.

Data Sources

To assess the state or impact of ICT and ICT education, I referred to either secondary (published) statistics or primary statistics that I produced from data collected from surveys. Most of the data in the study are secondary because of the wide scope of the study. Some sources are disparate and often data sets are incomplete or do not refer to the same periods. Most recently available data have been used whenever it has been possible.

From an international perspectives, the following sources have proved useful:


Data and information on Singapore were extracted from Educational Statistics Digest (1997), Tan (1998), (gurukal.ucc.American.edu, November 14, 2001) and Nanyang’s Statistical Data Locator (ntu.edu.sg, April 10, 2002).
In England, Russell and Drew (2002) reported an ICT survey in Schools in England 1998-2001 from the Department of Education and Skills (dfee.gov.uk/research, November 18, 2001). The National Grid for Learning (NGfL) is the national telecommunications network infrastructure for education. BECTA (British Educational Computing and Telecommunications Agency) that is responsible for the contents, usage, etc. BECTA is a rich source of data and information.

In the U.S., there were data from Children and Computer Technology Survey 2000, which appeared in “The Future of Children 2000” from The David and Lucile Packard Foundation, USA. (futureofchildren.org, November 11, 2001); Massachusetts Technology Plan 2000 (doe.mass.doc, February 20, 2002); Getting America’s Students Ready for the 21st Century: Meeting the Technology Literacy Challenge (ed.gov, February 20, 2002b); E-learning: Putting a world-class education at the fingertips of all children – the national technology plan (ed.gov, February 20, 2002a); Online Population and Workforce Education compared the distribution of population, their qualifications and technology jobs that were available in metropolitan areas in U.S (neweconomyindex, December 10, 2001a; 2001b);

Secondary data on Mauritius were obtained from the following sources: Education Statistics 2001 and Telecommunications indicators 2000 from (stats mauritius.gov.mu, June 5, 2002); National Computer Board’s ICT Usage Survey 2001: A survey on the ICT adoption of businesses in Mauritius (ncb.intnet.mu, March 23, 2001); Report of the sub-committee on demand for Information Technology Manpower 2001-2006 (ncb.intnet.mu, May 5, 2002); Report of the sub-committee to
take stock of the state of E-education and E-training in Mauritius (ncb.intnet.mu, May 25, 2002).

Trends in Computer Systems in Education:
Past, Present and Future

Education technology was born from the time when an enterprising teacher used a stick to draw in the dirt to illustrate his or her idea. From 1920 – 1985 the emphasis was on radio and television. However, Satler first mentioned the use of technology per se in education in an interview in 1948 and the first instructional use of computers was a flight simulator used to train pilots at MIT in 1950. Nine years later, IBM 650 was used in public schools in New York to teach elementary students binary arithmetic. During the mid-seventies, large-scale projects in computer-assisted instructions (CAI) on mainframe computers were available in schools, colleges and universities. In 1977, the first microcomputer was used in schools and became prevalent in the next two decades. In 1979, the first National Education Computing Conference (NECC) was held and has remained the largest and most successful of its kind. In Mindstorm, Papert (1980) challenged educational technology goals and directed educational computer applications to Piaget’s constructivism through Logo and Lego Logo courseware. Papert (1980) claimed that microworlds, being rich in experiences, could facilitate the development of the stages of mental growth. He started work on computer education in the era of the mainframe computer and wished that the time would come when the students could afford small computers, like pencils and exercise books. Regian and Shute (1992) edited a collection of papers on cognitive approaches to automated instruction. Some

The new microcomputer software market has been driven primarily by educators and later by businesses. The Minnesota Educational Computing Consortium (MECC) provided a lot of the educational software and MicroSift and EPIE carried out the evaluations. Teachers are not programmers and vice versa. The quality of the software remained low. Authoring systems are typically weak, and permit only framed-based systems (i.e., click button and see open graphic or animations). For successful educational software educators need to team up with programmers to work on the instructional design and contents of the courseware.

The curriculum has evolved from Computer Awareness, Computer Literacy, Information Technology Literacy to Information Literacy. Computer Literacy, originally defined as learning about the computer, programming skills and productivity tools, such as word processing, became popular. Today, the term refers to knowledge of computer applications or skills that are constantly changing. Computers and telecommunications converge when computers are connected together as a network to share expensive resources, and Information Technology became fashionable. The emphasis on
communication through computers and the emergent technologies bear the name of Information and Communication Technology (ICT). Now Information Literacy or Information Fluency (ed.gov, February 20, 2002) or computer fluency (futureofchildren.org, November 11, 2001) is the current literacy that emphasizes information handling and usage.

There are four dominant trends (with the last one being the most acceptable) in educational technology as expressed by the following associations:

The Association for Educational Communications and Technology centers on audiovisual media communications and views educational technology as a “branch of educational theory and practice concerned primarily with the design and use of messages, which control the learning process.” See TechTrends.

The International Society for Performance Improvement holds the view that “instructional systems approach is based on behaviorist theories that focuses on systematic approach to designing, developing, and delivering instruction matched to carefully identified needs.” See Performance Improvement Journal and Performance Improvement Quarterly.

The International Technology Education Association focuses on industry trainers and vocational teachers and believes that “schools should prepare students for work force learning about technology as used in the “real world” is essential.” See The Technology Teacher, Technology and Children, and The Journal of Technology Education.

The International Society for Technology in Education was founded by trainers and educators and computer professionals. It focuses on both instructional and support
applications of computers. It has produced the National Educational Standards for Students and Teachers (NETS). See Learning and Leading with Technology (formerly The Computing Teacher), Journal of Research on Computing in Education.

Restructure, Change and Culture Issues

The upheaval of the Information Revolution impacts the society profoundly. The relevance of the curriculum, teaching and learning and the school as an institution are undergoing changes. ICT is emerging as an effective tool to manage the changes.

Stonier and Conlin (1985) wrote that education for an industrial society centered on teaching the Three Rs: Reading, wRiting and aRithmetic. Its aim was to produce a disciplined workforce – punctual, conformist and specialized – to operate the brute machinery of the nation-state. Education for an information society will center on the three Cs’: Children, Computers and Communication. Its aim will be to produce a creative workforce – adaptable, entrepreneurial, interdisciplinary – to help solve the problems of this planet. And Papert (1980) raised national consciousness about the potential of technology to change the educational system.

Since the 1990s, schools in the United States have increasingly undergone restructure (Urch, 1996) or transformation to keep pace with new life skills and the world of work in the Information Age and Byrd and Maloy (1996). Advocates of restructuring have suggested skills that include the following: problem solving and critical thinking, information handling, global awareness, technology skills and ability to cooperate and collaborate with others (Simonson & Thompson, 1994). The new views are about making students active learners through authentic tasks and projects,
and teachers become facilitators of this learning experience. ICT provide natural tools for pursuing new goals and approaches for schools in new ways. Computer-based materials are just one component of resources available to educational system. Integration of technology as a tool to advance learning in the content areas adds to the effectiveness of other resources and teacher created activities.

Educators must keep pace with technological advances. Often times technology changes faster than the educational environment. Often the fast pace (change) of new technology has resulted in education meeting decisions in frustration and confusion rather than careful calculations, so that many capabilities are out of reach of children and teachers. Microsoft publishes new edition of the operating system and application software Microsoft Office for the personal computers (PC) every two years. While new generations of machines and new editions of software offer more computing power and extended possibilities, the problems of replacement affect the schools that have limited resources. Business and industry must do their part in providing economical technology solutions. And Chang (1994) insisted that change has to be managed properly.

However, Oppenheimer (1997) held the view that ICT investment is too high and is done at the expense of other needs in education. Opponents argue that the benefits of ICT have not been proven beyond reasonable doubt. They compare ICT to other hyped tools, like radio and television that have not delivered the good in improving learning.

Carreon (1995) discussed the culture issue of importing software to be used in the Philippines. Often, English is a second language that only the educated people can use. But the pupils in primary and lower secondary schools in non-native speaking
countries cannot use it. Some main foreign languages are now available on the Internet. Foreign languages cannot capture the “inner voices” of people. Using IT implies some amount of deculturalizations, as movies do. Finland, which has the highest density of cellular phones and Internet hosts, has been moving towards a culture-oriented information society.

In a study “Learning to Change” (OECD, 2001) about the use of ICT in the advanced countries, it was reported that traditional things have been done in different ways, ... using Internet material to support conventional teaching practices, ... employing didactic software to rehearse basic skills, ... merely replicating existing learning methods in technological form. If ICTs are to fulfill their potential, innovation and change are called for at all levels of the school environment (Haddad, Wadi D., 2002, p. 6). The challenge is to align learning technologies with sound pedagogy and instructional design and try to do with virtual systems of delivery what could not be done with conventional models.

Learning does not have to be work. Increasing the “play quotient” in school-home interaction can yield powerful results. For example, the popular electronic board game “Carmen San Diego” (Broderbund, 1990), which has sold over two million copies, crossed over from retail sales to school use in teaching geography; Papert’s Lego Logo, which teaches simple programming using the popular plastic building bricks, links the home toy box with the school technology laboratory. These wares blur the line between playing and learning (electronic-school.com, September 20, 2001).
Teacher Education and Training

Teacher training is well covered in the country case studies of Singapore, United Kingdom and United States. Every country faces the problem of backlog in teacher training or retraining. Guruvadoo (1986) used a cascade model to multiply the number of trainers who were being trained to teach teachers. In-service teachers’ enthusiasm eventually vaporizes and they drop off when they are faced with the rigorous demand in terms of responsibilities, time and energy, and often without extra remuneration. Pre-service teachers prove more successful and they link up university support to training of other ICT teachers at school. But many teachers do not feel confident to integrate ICT into the curriculum. Later technology coordinators and technicians were hired to support ICT teachers in class.

Development of technology materials and integration strategies are time intensive and should not be a classroom teacher’s primary responsibility.

Teachers will always be needed. However, the definition of learning environments is changing. So the identity of classrooms must change. Our models of effective instruction must change too. Educators must be more than “sage on the stage” and “guide on the side” (Roblyer, 2000). Today’s teacher must be willing to be a participating learner in the classroom; one who will take the same risks and not always have the right answer; and be a veteran learner in a network of learners called the classroom.
Learning

In the twentieth century, there are two main psycho-pedagogical schools of learning, namely, Skinner's behaviorism and Piaget's constructivism. Behaviorism aims to automate the stimulus-response-reinforcement process. Constructivism focuses on the learner who interacts with sensory data and creates his or her own model to explain nature (exploratorium.edu, October 23, 2001). Each produces a derivative technological tool: programmed instructions from behaviorism and Papert’s Logo and Lego-Logo, case-based system, collaborative system, inquiry system and simulation system are derivatives from constructivism. The learning model for both tools is learner-centered and focuses on the learning process. But, programmed instruction fell in disfavor on theoretical and practical grounds.

However, from the above theories and classroom observation of teaching methods ranging from the traditional teacher-centered model to the contemporary learner-centered model, there is room for a third model of mediation that highlights teacher-learner relationships that are conducive to exchange and participation. The mediation model deprives IT of its role as a regulator and centralizer around which learning is organized. This model withdraws technology to the periphery of the teaching process and transforms it into a tool, which supports the educational relationships. Many technological tools exist that reinforce and respect the educational relationship favoring interpersonal exchanges within a group of teachers and the learners.

Telecommunications, video-conferencing and audio-conferencing provide the means for group communications (e.g., IBM Lotus Notes or e-Groups) and remote
online tutoring. Collaborative learning supports the mediation of interpersonal exchanges through interaction between learners in computer conferencing. The mediation model reduces the dependence on technological resources and places interpersonal relationships at the heart of the learning process (myweb.worldnet.net, October 23, 2001).

Vygotsky and Bruner favored the mediation model. Vygotsky believed that children's understanding is shaped not only through adaptive encounters with the physical world but learning is a transaction, an exchange between the learner and a more experienced member of his or her cultural group, for example the teacher (Vygotsky, 1962; Edwards & Mercer, 1987). They both accept constructivism but reject individualism. Constructivist Samuel Papert applied technology to learning through Logo and Lego Logo, and produced micro-worlds, which are information rich and contextual, and provide a virtual environment for simulations of experiments.

Learning is a social activity associated with peers, teachers, family and casual acquaintances (Vygotsky, 1978) and mentors can be more involved in schoolwork by connecting to the school network.

Research, Evaluation and Dissemination

There are seven dimensions for evaluating technical progress of a school: learner, learner environment, professional competency, system capacity, community connections, technology capacity and accountability (Lemke & Couglin, 1988). There are National Educational Technology Standards for K-12 students and Teachers, which are published by the International Society of Technology in Education (ISTE NETS).
Mormund described research and evaluation in educational technology (uo.oregon.edu, April 28, 2002) or (mff.org, July 15, 2002).

All the findings need be disseminated widely and the Web serves the purpose effectively. Conference, seminars, workshops newsletters and journals are platforms where the professionals brainstorm and negotiate their best practices.

Planning

Haines (1995) and (shefc.ac.uk, May 19, 1999) stated that planning achieves the following: it sets direction for the institution (or country), allocates resources within the institution, and examines the alternative courses of action available. Improved planning leads to: improved decision-making, higher profitability and lower risk. Strategic planning is the continuous process of systematically evaluating the nature of the business, defining its long-term objectives, identifying quantifiable goals, developing strategies to reach these objectives and goals and allocating resources to carry out these strategies. We begin by asking what business are we in (reflected in the mission statement), where were we, where are we, where are we going and how do we get there. Scanning the environment enables one to take stock of the other players' (competitors') activities. A SWOT (strength, weaknesses, opportunities and threats) analysis (Mintzberg & Quinn, 1991) for the country is carried out and a strategic plan is developed. Often, over-ambitious plan is 'inactionable'. And strong turbulence due to fast change and innovations can destabilize the plan (Ansoff, 1979). The plan needs to be continuously updated to reflect the actual situation.
Caillods (1989) from the International Institute for Educational Planning, UNESCO, discussed the nature of educational planning in the span of twenty years, and how economic and social change impacted education in various parts of the world from the sixties at a time of unprecedented growth and educational development to the late eighties that were beset with financial difficulties, the decline in the quality of education, the problems of administration of education, and the out-of synch relation between education and employment. This is due to the following three factors: first, world economic crisis has affected economic growth or created a very unstable situation and this limits the resources available for education, and weakens the potential of integration of trained young people; secondly, the grand myths of education as a motor for development and a great leveler in society have waned, thereby losing the high priority in the allocation of public resources; and, thirdly, the acceleration of technological development in information and communication sciences is making it more and more difficult to forecast industrial techniques and employment opportunities in the medium and long term. Finally, the State seems less and less able to meet all the educational demands made on it; private education is expanding; and new forms of education outside the traditional school systems are emerging everywhere. Strategic planning must adapt to the new environment of accelerated change.

One major difficulty in planning is to estimate the cost of a project or program. The White Paper of 1999 provided a Guide to Planning for the Total Cost of New Technology (doc.mass.doc, February 28, 2002) from the Department of Education. Massachusetts has guidelines for planning and costing. Maryland published its
guidelines in IT Policy: The Foundation for Policy (dbm.state.md.us, September 6, 2001).

The best practices of eight OECD countries (Canada, Germany, Ireland, Japan, Netherlands, Sweden, U.K. and U.S.) are discussed in developing national policies and programs to accelerate the effective use of IT in support of industrial competitiveness (Arnold, Guy, & Hanna, 1995). The role of government in unleashing private sector response, promoting IT industry, diffusing technology and focusing on strategic elements of national information infrastructure is explained in “The East Asian Miracle and Information Technology: Strategic Management of Technology Learning (Hanna, Boyson, & Gunaratne, 1996).

In developing the strategic plan, I will keep in mind the proposition of Delors (1996), the chairman of the UNESCO commission on education, who described what should be the aims of education and the type of education that we need in the 21st century. Bray (1991) from The British Commonwealth Secretariat in London, focused on the role of Ministries of Education in Small States, and Bray (1992) discussed the nature of educational planning in small countries in international settings and how to make small beautiful. I will interview Professor R. Lamusse, an economic adviser at the Prime Minister’s Office in Mauritius, on the strategy of a small island economy that Mauritius should adopt.

The first National IT Education Plan from the Ministry of Education (MOE, 1992) contained a wish list with no evaluation scheme, and, as such, was partly realized. Guruvadoo (1998b) presented to the Minister of Education and Scientific Research a Strategic Plan and an Action Plan for Information Technology in Education.
Unfortunately, some so-called advisers warped the new Strategic Plan of the Ministry of Education and Scientific Research (MOESR, 1999), which became also a mix bag of promises and realities; however, the new plan was central to innovation in Education; it aimed at anticipating the needs of the 21st Century and producing a workforce of excellence, and it included the provision for continuous training of teachers as a major and worthwhile investment.


Several States in North America have implemented their integrated Information Technology (IT) plan for education. I looked into some universities’ integrated IT plans that support campus-wide IT operations and collaborations with colleges and satellite schools in certain cities. In particular, I have studied the Strategic Plan for 1997-2001:
“Towards a Commonwealth of Learning”, University of Massachusetts at Amherst (umass.edu, March 23, 2001), the University of Central Florida’s “IT Plan” (fccj.org, March 16, 2002), the University of Arizona’s “Information Technology Strategy Plan” (ict.arizona.edu, September 5, 2002), and Maryland’s “Information Technology Direction” (dbm.state.md.us, September 6, 2001), which discussed about developing an IT infrastructure that would propel the state into a leadership role in the information age. It is about the State’s shared vision of improving the quality of education, creating jobs and strengthening business opportunities, and making communities safer, within the context of universal citizen access and maximum customer satisfaction.

Future

Defining the future in a field of fast changes is like crystal ball gazing. I have taken care in reading the following:

The Interuniversity Communications Council discussed planning with and for technology in higher education (EDUCOM, 1975). Other useful sources are: U.S. Global Commitment for the International Consultative Forum on Education for All (Fiske and O’Grady, 2000); “Enable the Future: Linking Science and Technology to Societal Goals.” Carnegie Commission (1992); and Bernhardt et al. (1998) discussed about rethinking schools for the 21st century. The Central Intelligence Agency projects the future in The 2015 World, according to the CIA, which is available online through Asia Times (atimes.com, May 16, 2001). Also, Mormund explains how digital technology will transform schools and improve learning (uoregon.edu, April 28, 2002).
Finally, (europa.eu.int, March 16, 2002) discusses the design of tomorrow’s education in the promotion of innovation with new technologies.

Summary

The chapter contains the main theme of Computer and Information Technologies in education against the background of the Information Revolution, and two parts. The literature review has explored the conceptual platform of the study in terms of the theoretical underpinnings of the components of a possible conceptual framework for ICT education: infrastructure, equity, partnership, data sources, trends in computer systems, restructure, change and culture issues, teacher education and training, learning, research, evaluation and dissemination, planning and the future.
CHAPTER 3

METHODOLOGY

This chapter introduces the research methodology, maps out the methods and data to be collected to the research questions that were asked in Chapter 1, and describes the research design to collect the necessary data and information.

Introduction

Based on the realities of the economic, technological, social, cultural and political backgrounds, different countries develop, adopt or adapt Information and Computer Technology (ICT) to enhance education. Although the technology is universal, each nation chooses its flavor of ICT education according to its specificities. One main determinant is economic status. Countries are broadly categorized as industrialized, newly industrialized, and developing economy. At a higher abstraction level, we expect to see a core of desirable features that cut across the different economic groups. This core system might be scaled down to fit the budget or place technology either at the center or periphery of learning experiences, and adapt it to the social and cultural realities within each group or country.

Information and Computer Technology (ICT) education is common in industrialized and newly industrialized countries (NICs), to a lesser extent in some developing countries, and practically non-existent in poor countries. In order to develop a strategic plan for ICT education in Mauritius, it is important to understand the evolution, philosophy, trends, implementation and research in ICT education in the
broader context of education and development in other countries. Their experiences were analyzed and the best practices in the local context synthesized through a framework that yielded a lens, which would be applicable to a country or state implementing ICT education. The lens was applied to Mauritius as a case study to find out what would be effective strategies to enhance and promote ICT education in learning and teaching. Finally, the framework was modified for possible technology transfer to some developing countries, in particular, Africa.

Countries have developed their own educational systems or have adapted existing ones to varying degrees of success. The West has a rich history of educational technology development. The advanced countries pioneered computer education. The 'tiger' nation states: Singapore, Hong Kong, Taiwan and the Republic of Korea (NICs) of South East Asia are successful models of development that are different from those in the West (Ashton, Green, James and Sung, 1999). There are also some developed countries in Europe, like Finland, Sweden, Norway and France, and some developing countries, such as India, Malaysia, Chile, etc., that provide interesting lessons for Mauritius, such as their economies, their Computer Education plans, and their successful links between education and training. However, for the sake of space and time, we focused, in Chapter 4, on three country case studies, namely Singapore, United Kingdom and United States, about the development of ICT education. We resorted to statistical surveys as they provided up-to-date, relevant and reliable data to assess the present situation of Mauritian education and the state of ICT Education. They could be used to make reasonable forecasts.
In order to look ahead and develop a strategic plan for Computer Education, there is value to look back at the past and also examine the present. Traditionally, changes in education take time. The evolution of the educational system to present day reflects the prevailing philosophies and forces at work, and delineates the strengths and weaknesses of the system. A historical approach is used to trace the development of strategic planning in education in Mauritius, see Chapter 6.

Scanning the environment tells us who are the key players, competitors, and opportunities and threats in relation to our strengths and weaknesses. Building on the strengths, fortifying the weaknesses, we can seize the opportunities while taking care of the threats.

This exercise leads to a strategic ICT education plan for Mauritius. The success of the plan depends on the collective wisdom of the experts.

Research Approach

A multi-pronged approach is used.

1. A case study approach is chosen because it captures the essence (depth) of a current phenomenon for a typical context. By repeating the case study for different contexts, it gives coverage (breadth) of the method. The different case studies are treated as sub-case studies, thus improving validity. The method enables the researcher, within the constraints of space and time, to learn on a small scale the best practices from the experiences of other countries. Later, the research can be scaled up to a full-scale study for a real national strategic plan.
2. Modeling a framework to develop a lens that can be applied to assess the needs of a country in terms of ICT education. This can be done through analysis and synthesis of the case studies.

3. Case Study of Mauritius. First, a historical one to trace the evolution of the educational system and the issues dealt with in the previous plans for education. Secondly, bottom up and top down approaches are used in fact-finding and needs assessment through surveys of all stakeholders, including leading personalities and of policy makers; the data are collected and evaluated; some contextual factors and metrics are produced. Thirdly, these indicators are used, together with a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis (Mintzberg & Quinn, 1991) and the application of the lens, to formulate the strategic plan for Mauritius for the period of 2003-2010. Fourthly, consensus on the strategic plan for Mauritius is achieved through anticipatory research and ownership of stakeholders in a consultative process.

4. Tweaking the model. The above framework is adapted to the realities of poor countries and the resulting lens applied in an attempt to transfer technology to poor countries, in particular to Africa.

**Population and Data Collection**

A strategic plan is based on data. To collect data or information, we need (1) to define the population under study or stakeholders of the plan for representativeness and ownership, and (2) sampling frames, and (3) the sampling schemes.
Stakeholders

The population under study is the stakeholders. There are those that are directly involved with the school and the Ministry or Department of Education, and those that are directly or indirectly linked to school. The first group consists of head teachers or rectors, administrative staff, teachers, students and parents. There is a direct link between the school and the administrative and supervisory cadre of school inspectors (and the oversight from the Permanent Secretary and the Minister of Education). The indirectly linked group is the community, and the private and public sectors. Some members of this group have valuable experiences and knowledge, and can influence the system of education and are demanding for participation and funding in, and accountability from the school. Business wants to improve the quality of output as their future manpower, to fund or provide resources, and seeks out investment possibilities.

Community, Public and Private Sectors

One group of stakeholders is the community, the civil societies, and the private and public sectors, who have other valuable experiences and knowledge, and can influence the system of education.

We had to choose a sample to form a panel of experts who were originally difficult to identify and reach. Fortunately, the researcher had local information about people “in the know” to recommend who could be good participants as panelists. A representative selection was made on a quota basis. A total of 25 policy experts and scholars, (20 local and 5 abroad) from across a broad range of fields participated in the
study in the interview round or subsequent two survey rounds over six months. Policy
shapers were chosen from politics and government, business, industry and labor,
science and technology, education, cultural and academic fields which emerged as
important from background reading, particularly in the area of ICT education. They
were selected on the following criteria (i) “future orientation - ability to envision
changes and opportunities in the future; leadership - demonstrated through public
interventions, publications or high esteem amongst their peers,” according to Cogan and
Derricott, (1998 pp.15-16); (ii) interest in ICT, Communications, Education,
Economics, Sociology, Public policy, and Employees’ Unions; and (iii) knowledge of
what was happening elsewhere in the world. (Cogan & Derricott, 1998) suggested
engaging a heterogeneous panel of experts in a collaborative effort, to solicit, integrate
and interpret their collective wisdom until the objectives and strategies stabilized in
usually three passes. The results were used to develop a consensual strategic plan for
ICT education in Mauritius.

School Population

The other group of stakeholders is directly related to the school. In 2000, in
Mauritius, there were 130 secondary schools that were locally called colleges and were
on a three-term school year. They correspond to middle and high schools in the United
States. There were 32 state colleges on the mainland (Island of) Mauritius, 2 in
Rodrigues Island (Rodrigues is the 10th district and is about 350 miles offshore of
mainland Mauritius); 18 confessional (owned by religious groups) colleges on mainland
and 1 in Rodrigues; and 79 privately run colleges. They were all funded by the state.
The Ministry of Education managed the state colleges only. The confessional and other private colleges, operating under the umbrella of the Private Secondary Schools Authority (PSSA), were flexible in their hiring of staff, in management and investments. They were more variable in terms of infrastructure, social class of students and performance, depending on rural and urban regions. They were funded by a matching grant from the state for their investment in ICT. There were boys only, girls only and some co-educational schools (co-ed). There were 92 out of 133 schools with a computer laboratory, which determined the status of officially recognized classes for the study of Computer Literacy, Computer Studies and/or Computing/Computer Science.

Sampling Frame

Those who are directly involved with education and the schools, namely, the Ministry of Education, the Inspectorate, the Administration, the teaching staffs, the students and the parents form an easily targeted sampling frame whereas the others have no such sampling frame. Different sampling schemes had been used on different populations. The first group consisted of various strata and a stratified random sample was appropriate. For the other group without a sampling frame, a pseudo-random quota sample was used.

For this research study, there were six broad groups: decision/policy-makers, parents, school inspectors (senior education officers), and school-based front liners who were the rectors/managers, teachers and students. Seven sub-samples samples were needed, namely, (1) for the policy shapers and decision makers, (2) for Inspectors who were administrators with a lot of experience with schools and related problems of
staffing and resources, (3) rectors/principals or managers, (4) students, (5) teachers and (6) parents, and (7) principals/managers of the private schools without computer laboratories to find out why they had not invested in Computer Education when it has been in great demand everywhere. (The teachers and students were not included here as they shared the same characteristics as other teachers and students countrywide).

Data

Data can be primary or secondary. Primary data are collected from the source for the purpose of the study where as secondary data are statistics from published sources.

Primary data were collected from statistical surveys, especially for Mauritius. Seeking consensus over the proposed strategic plan is done through anticipatory research using the Ethnographic Delphi Futures Research (EDFR) (Cogan and Derricott, 1998).

Secondary data have been used wherever they were available and adequate for the purposes of this study. The case studies on ICT education relied mostly on secondary information from international sources, like strategic plans, studies, surveys, reports and other publications that were available online or in hardcopy. Sometimes, certain statistics were available on the same topics from different sources, and sometimes there were discrepancies when collated. Refereed sources were preferred; sometimes, for data without freak values, a mean of the values might be a better estimate. Also, certain data or most recent reports were not available. So, the old data were identified as such and kept as second best, and care was taken in the interpretation. The case studies relied mostly on secondary information from international ICT
education strategic plans, studies, surveys and publications that were available online or on hardcopy.

Over a period of seven years relevant documents related to the field of Information and Computer Technology for teaching and learning were searched and read. However, more recent ones have substituted older ones as the materials have become available, as many things have changed. The main features of interest were noted, such as, ICT infrastructure (computer systems, networking and Internet), curriculum development, teacher training, learning, school connection with the community, public and private sector investment, cost, funding, incentives, trends and future developments. An analysis and synthesis of best practices in a few countries were analyzed and a lens was developed to examine ICT education strategic plans of a country or state.

The survey using questionnaires and focused interviews were carried out starting on the second week in January 2001 during the second school term.

Mapping Methods and Data to Research Questions

To answer each question, appropriate data are needed. In order to collect the data, appropriate methods are applied. So the exercise is about mapping appropriate methods and data to the research questions. The complex nature of the study calls for a mixed bag of methods, as summed up in the tables 3.1 and 3.2, on pp. 55 and 56.
Table 3.1.
Mapping Methods and Data to Research Questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Method</th>
<th>Data</th>
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<tbody>
<tr>
<td>1. What are some important current issues in education, and how can ICT address them? In particular, how can we use ICT to restructure the educational environment to maximize educational benefits?</td>
<td>This is a broad inquiry about a topical subject and a current revolution. For the purpose of this study, the scope of the research is bound in space and time. A case study method is used to focus on three country studies that are representative ICT education system in developed and newly industrialized countries.</td>
<td>To collect data and information on (i) strategic education technology plans to analyze the issues and evaluate attempts at solving them, (ii) on the state-of-the-art of learning and teaching. The case studies were constructed from materials obtained while researching related documents, either hard copies or online, reading discussion groups (special interest groups called SIGs), being posted on listservs, and emailing.</td>
</tr>
<tr>
<td>2. What is an appropriate framework to analyze and make a needs-assessment of ICT education? Can we develop a lens to be used to plan ICT for other countries?</td>
<td>Modeling. To analysis and synthesize the above case studies in terms of an appropriate framework</td>
<td>To analyze the above data within a suitable framework and synthesize the findings in order to develop a lens to examine a country’s needs and plan for ICT education.</td>
</tr>
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</table>
Table 3.1, cont’d.:

<table>
<thead>
<tr>
<th>Questions</th>
<th>Method</th>
<th>Data</th>
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<tr>
<td>3. What is an appropriate strategic ICT education plan for Mauritius?</td>
<td>Historical, statistical surveys, SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, application of the developed lens within the above-mentioned framework, and EDFR (Ethnographic Delphi Futures Research) (Cogan and Derricott, 1998). Historical documents and past strategic plans are reviewed to find out the main issues and philosophies in attempted solutions as revealed in the past strategic plans. The current situation and possible solutions are captured through statistical surveys of stakeholders of ICT education. The lens developed from the framework is used to make a needs-assessment. A SWOT analysis is performed to generate a proposed strategic plan. Finally, EDFR is used to bring consensus to the plan.</td>
<td>To collect appropriate data that will facilitate the development of a strategic plan for Mauritius to enhance and promote ICT learning and teaching. Data on contextual factors and indicators are collected to compute assessment metrics. Finally, the proposed plan is subjected to a panel of experts. Feed-forward and feedbackward data are gathered on a three-cycle loop of “generate and test” opinions.</td>
</tr>
<tr>
<td>What have been the main issues in education in Mauritius?</td>
<td></td>
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</tr>
<tr>
<td>What is the needs-assessment in terms of ICT education?</td>
<td></td>
<td></td>
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<tr>
<td>4. How could the above model be adapted in a technology transfer to developing countries?</td>
<td>Modeling. Survey literature about ICT implementations in developing countries and identify the characteristics and limitations. Modify the above model.</td>
<td>To collect data and information about how to apply the above framework for a technology transfer to the developing countries, with particular reference to Africa.</td>
</tr>
</tbody>
</table>
Research Design

Note on Methodology

The methodology used for the study was statistical survey of Group 1 and an Ethnographic Delphi Futures Research (EDFR) model (Cogan & Derricott, 1998) for Group 2. The survey was based on a stratified random pseudo-random sample of Group 1 and the data collected were qualitative and quantitative. They were processed and inferences were drawn. The results from a representative sample were valid, reliable and generalizable over the whole population. For Group 2, an opinion survey of all members was carried out on a first round. On the second round, the findings of both surveys were presented to Group 2, who acted as panelists, and commented on the results. On the final round, the comments of the previous round were presented as recommendations to Group 2 again and their opinions were sought. By then, there was near consensus on most recommendations that went into the final strategies. There were a few least favorable ideas and they were considered carefully and often not included unless they warranted special treatment.

While statistical and opinion surveys are standard methods, the Ethnographic Delphi Futures Research (EDFR) model is relatively new and needs some explanations. EDFR is based upon an adaptation of the Delphi method (Linstone & Turoff, 1975; Linstone & Simmons, 1977). During the 1950s and 1960s, the Rand Corporation, under contract from US Air Force, developed the Delphi method for anticipatory research. It was conceived as an intuitive, exploratory method to solicit and synthesize the forecasts of a group of experts regarding problems that did not lend themselves to precise
analytical techniques but that could benefit from the application of a carefully derived collective judgment.

The basic philosophy is that human judgments represent legitimate and useful inputs in addressing research problems that are long-range, ill defined, highly complex, and/or lack a well-developed theoretical foundation. The judgment of a group is likely to be superior to that of any individual, especially if judgments are arrived at in an interactive manner involving carefully structured sharing of information. The responses shared anonymously are likely to be superior (more numerous, detailed, creative and candid) to those publicly identified with their source because participants who respond anonymously are not subjected to the biasing effects of dominant individuals, group pressures towards conformity, irrelevant communication, and fear of public disapproval (Cogan & Derricott, 1998, p.78).

The Delphi method is a tool for social systems design due to its demonstrated capacity to build consensus and to enhance understanding of complex issues by engaging a ‘community’ in developing a shared vision of ways of life that are possible, desirable and sustainable, and feasible strategies to enact that vision (Cogan and Derricott, 1998). “The redefinition of contextual realities facilitates the generation of new options and may create impetus for change” according to (Scheele, 1975, p. 43). Governments and businesses commonly use EDFR to make long-term projections in order to develop appropriate policy directives. “In education, the Delphi method has been used effectively for applications such as curriculum planning and development, and goal setting” maintained (Martorella, 1991, pp. 83-84), and an educational policy due to its ability to accommodate multiple competing insights and interests. (Cookson, 1986).
Focused Interviews

There were three sets of focused interviews for policy shapers and decision makers (sample 1), Principal Inspectors (sample 2) and Principals/Managers of the private schools without computer laboratories (sample 7), see page . Sample 2 dealt with the Inspectorate who enforced the laws and regulations in schools, and oversaw the teaching of ICT education and its implementation in terms of computer systems. There were two Principal Inspectors (Principal Education Officers), one from the Ministry of Education and the other from the Private Secondary Schools Authority (PSSA). A formal interview was conducted with the above two Officers.

For sample 7, the principals/managers of the private schools without computer laboratories were interviewed to understand why they had remained outside the current trend of computer education at school. Finally, for sample 1, a set of panel experts was chosen. There was no sampling frame and the population was scarce and difficult to reach because they were typically too busy. A balanced (subjective) selection, in terms of their meaningful backgrounds with respect to the orientation of the study, was made on a quota basis, and the researcher did his best to reach them by planning ahead and being persistent. Some intermediate contacts were useful. Focused and somewhat free form interviews were carried out.

Questionnaire-Based Stratified Random Sampling

Sub-populations of Inspectorate, Rectors/Principals/Managers, students, teachers and parents constitute the components of a stratified random sample. The strata were: (i) ownership: state (S), confessional (C) and private (P) schools, (ii) geographic...
locations: urban (U), rural (R) and Rodriguan (Ro) schools, (iii) type of schools by gender (boys (B), girls (G) and both gender (co-ed.) (C), and (iv) school population with substrata: (a) rectors or managers, (b) teachers: IT and non-IT (c) students with sub-substrata: middle (forms I-III which all do Computer Literacy), junior high (forms IV-V which selectively do Computer Studies for Cambridge School Certificate Examination (O.L.)), and senior high (forms VI Lower and VI Upper, and Third Year) who selectively studied Computer Science or Computing or Information Technology, depending on availability at schools, for Cambridge Higher School Certificate (A.L.). Finally, a questionnaire was distributed to parents who were an important segment of the stakeholders.

Within each stratum and substratum, proportionate simple random sampling was taken from the sampling frames which were (i) the lists of institutions, with the rectors or managers from the Ministry of Education and the Private Secondary Schools Authority, (ii) the lists of teachers within each school, and (iii) the lists of students from the attendance register for each form at each school. Finally, selected sub-samples were aggregated over the main sample, for their representativeness, participation and ownership of the eventual strategic plan. Their values were shared and negotiated for the overall success of the final plans.

The constituent samples were drawn, wherever possible, using simple random sampling procedure from a table of random numbers. The sampling fraction was chosen to be 1/6 or 16.7 percent that was fairly high (Moser, 1974).
Sample

The sample was stratified by school types, geographic region, gender, and school population (including parents). The original sample random sample was of size 1346 for the school community and 280 parents. However, following the results of the pilot survey (see next section), the final sample size was drastically reduced to 122. Also it was noted that 37 out of 79 the private colleges did not have a computer laboratory, and this was a cause of concern. State schools were more or less homogeneous. Only the principals of schools without computer laboratories were included in the sample. And one class per form was chosen.

Table 3.2

Distribution of Secondary Schools and Those Selected

<table>
<thead>
<tr>
<th>Type</th>
<th>State</th>
<th>Confessional</th>
<th>Private</th>
<th>Private^</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Schools</td>
<td>32</td>
<td>18</td>
<td>42</td>
<td>37</td>
<td>129</td>
</tr>
<tr>
<td>Schools chosen</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Location</td>
<td>1R</td>
<td>1U</td>
<td>2R</td>
<td>2U</td>
<td>5R</td>
</tr>
</tbody>
</table>

^ With computer laboratory. *Without computer laboratory.

Key: R = Rural; U = Urban.

There was more variability in computer laboratories in private schools. Hence, more schools were chosen for this group. Then the schools were divided by rural (R) and urban (U) categories. Finally, all selected schools were divided by gender.

Table 3.3 shows the sampling methods used for the sub-populations, and the data collection instruments used for the various samples.
Table 3.3
Sample Numbers, Data Collection and Sampling Methods

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sub-population</th>
<th>Data Collection</th>
<th>Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Panel of experts</td>
<td>Free form interview</td>
<td>Quota</td>
</tr>
<tr>
<td>Q</td>
<td>Principal Inspectors</td>
<td>Focused Interview</td>
<td>Population</td>
</tr>
<tr>
<td>7</td>
<td>Principals/managers</td>
<td>Focused Interview</td>
<td>Random</td>
</tr>
<tr>
<td>3</td>
<td>Rectors/Principals</td>
<td>Questionnaires</td>
<td>Stratified random</td>
</tr>
<tr>
<td>4</td>
<td>Students</td>
<td>Questionnaires</td>
<td>Stratified random</td>
</tr>
<tr>
<td>5</td>
<td>Teachers</td>
<td>Questionnaires</td>
<td>Stratified random</td>
</tr>
<tr>
<td>6</td>
<td>Parents</td>
<td>Questionnaires</td>
<td>Stratified random</td>
</tr>
<tr>
<td>8</td>
<td>Administrative staff</td>
<td>Questionnaires</td>
<td>Stratified random</td>
</tr>
</tbody>
</table>

The sample sizes from the various strata for the questionnaire-based enquiry and from quota samples for oral interviews are shown below:

Table 3.4
Stratified Sample for Questionnaires-Based Survey

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Size</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>112</td>
<td>52 M, 60 F; 2 students/form (7)/school (8) w/ lab.</td>
</tr>
<tr>
<td>Teachers</td>
<td>40</td>
<td>5 teachers from each of the 8 schools.</td>
</tr>
<tr>
<td>Rectors</td>
<td>8</td>
<td>1 from each of the 8 schools.</td>
</tr>
<tr>
<td>Adm. Staff</td>
<td>8</td>
<td>1 from each of the 8 schools.</td>
</tr>
<tr>
<td>Parents</td>
<td>30</td>
<td>3 parents from each of the 10 schools.</td>
</tr>
<tr>
<td>Total</td>
<td>198</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quota Samples for focused interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pannel Experts</td>
</tr>
<tr>
<td>P Inspectors</td>
</tr>
<tr>
<td>Principals/Mgers</td>
</tr>
<tr>
<td>Total Sample</td>
</tr>
<tr>
<td>Intl.Experts</td>
</tr>
<tr>
<td>Overall Sample</td>
</tr>
</tbody>
</table>

Some schools might not have Form VI (lower and Upper), in which case the quota of students for that school is met by drawing more students.
The samples for the focused interviews were:

**Part 1-Quota sample of size 20.** Twenty people were interviewed. They were the Minister of Education and Scientific Research, Minister of Informatics and Telecommunication, Director of National Computer Board, Assistant Director of Central Informatics Bureau, Adviser to the Minister of Education on Education Technology, Adviser on Economic Affairs to the Prime Minister’s Office, Director of Industrial, Vocational, Training Board, Director of Mauritius Telecom, Head of Department of Computer Science at the University of Mauritius (UOM), Head of Department of Mathematics and Computer Education of the Mauritius Institute of Education, Director of the Mauritius College of the Air (for distance education and media production), Director of The Mascareignes Academy of Law, Education, Management, and Science (a private sector educational institution), Director of Mauritius Sugar Industry Research Institute, President of the Mauritius Chamber of Commerce and Industry, Director of Small and Medium Industry Development Organization, a Sociologist from UOM, an Economist from the Ministry of Planning, an information specialist (a journalist), a school psychologist and a leader of the teachers’ union. Whenever a designated interviewee was unavailable, a knowledgeable representative of the institution replaced him or her.

**Part 2 - Quota sample of size 2.** There were only two Principal Education Officers from the Inspectorate who were interviewed, one from the Ministry of Education and one from the Private Secondary Schools Authority (PSSA). Both were included because of their wide involvement with the Computer Literacy/Studies programs in secondary schools.
Part 3 - Quota sample of size 2. Principals or Managers of schools that had no computer laboratory were also interviewed to understand why they had not invested in computers. Two out of 39 schools were chosen; 1 in urban and 1 in rural areas.

In summary, the total sample size was 222 (stratified sample and quota sample).

Pilot Survey

A pilot survey of sample size 20 was conducted on the school population, parents and panel of experts to obtain information on the appropriateness of the questions and responses from the questionnaires.

The evaluation revealed imprecise questions, inadequate items of data, improper formulation of questions, scope of questionnaires, etc. The feedback was used to improve the final questionnaires.

The pilot survey revealed that responses from the schools from the various strata were not so much different. Hence, (1) Rodrigues was eliminated from the study in order to cut down on the cost of the study; this was feasible since Rodrigues had similar problems as mainland Mauritius, and (2) the size of the sample was reduced drastically to ease off the load of processing; all states schools were good and had the same facilities; all confessional schools were similar; most parents could not contribute ideas to ICT education except that they absolutely wanted their wards to study the subject at school. Much of the variability came from private urban and rural schools with or without a computer laboratory.
Instruments

The following instruments were used: (i) Abstraction of the speeches, statements and documents that were published in hard or soft copy from refereed sources; (ii) Somewhat free form or less-structured interviews but with the purpose clearly stated at the beginning, and then the facts and opinions were written down immediately after the interviews; (iii) Sets of questionnaires were used to record frontline people, namely, the rectors or managers, the teachers and the students, who were using modern or traditional systems. Copies of the questionnaires for rectors, teachers and students are included in the Appendix D. Finally, a questionnaire (see Appendix D) was administered to parents through their wards who were selected at random in class. Only a small sample of parents was selected as previous studies revealed that many parents were not knowledgeable enough to express their ideas about Computer Education, except that they wanted their wards to study the subject because it was important to get a good paying job, Often, the children had filled the questionnaires on their behalf. However, some informed parents did contribute in the project.

Data Analysis

The data from the questionnaires were verified for completion and errors, coded from a book of codes for the items that were not pre-coded on the questionnaires, input online and validated using the Statistical Package for Social Scientists (SPSS). The package was used for the analysis of the data and for some inference.
The responses from the free form interviews were processed manually for consistency, coherence and trends. Opinions are graded on a Likert’s scale (Moser, 1974).

Validity

Data were collected from focused interviews and survey questionnaires. Interviews were conducted over a quota sample of size 20 of policy makers, top-management and specialists. The sample was chosen in terms of the background and potential to contribute to the study. The diverse background of the people ensured both breadth and depth of knowledge to capture their visions of ICT education development. To make the interviews fluid and interesting, the sessions were conducted in a free form or semi-structured way. The focused interviews of 20 personalities, together with the respondents to the questionnaires, constituted the stakeholders of ICT education. The interviewees provided rich ideas and means for the subject contents, and subsequent implementation of the ICT education. Their participation in the process gave them ownership and made them partners of this educational revolution, and added perceived credibility to the study.

A list of issues that demanded quantitative and qualitative evaluation emerged from the literature and focused interviews. These were expressed in the questionnaires that elicited information from the respondents. Their permission was sought first by signing the appropriate forms.

A cover letter explained the purpose of the study and in what way everybody would benefit from the project, thereby motivating them for a high response rate. The
respondents were reassured that the responses would be anonymous and they would be free to express themselves, to avoid fear of reprisal. The surveyor provided a guide to filling the questionnaire to non-students and he met with the teachers to explain the directions and help survey the students to standardize the operations. No leading questions or suggestions were allowed to avoid bias. As the questionnaires were administered in class or office as appropriate, the response rate was high. Hence, the results of the survey were valid because the following were ensured: representativeness of the stratified samples, appropriateness of questions, minimal bias, high response rate and a proper analysis of the data.

Generalizability

Since the sample is a stratified random sample, the results are likely to be representative of the population. Statistically, we could obtain unbiased estimates of the population parameters from this sample, that is, it is safe to draw inference about the population from the sample. As all stakeholders were involved and the EDFR methodology secured consensus about the vision, mission, goals and strategies, the resulting plan got ownership, coverage, likely participation of the actual actors at schools and supporters in the communities, civil societies, and the public and private sectors.

Scalability

In 1984, Mr. Papayah Guruvadoo dreamt of an idea of using computers in schools at Sookdeo Bisondoyal Government School. There were no resources. In the
following year, he and two volunteers got involved in the first initiative at Dr. Maurice Cure Government School. In 1986, the Mauritius Institute of Education (MIE) hired him as Lecturer in Computer Education for training teachers in ICT. In the following year, the Ministry of Education and the MIE launched the Pilot IT Project in lower secondary schools. Soon after it became a mandated program with a curriculum and standards. Students have taken Computer Studies and Computing for final external examinations – the Cambridge School Certificate and the Higher School Certificate, respectively. Also, a pilot project was run in six primary schools with the assistance of the British Council. Finally, it will scale up to all primary schools in January 2003.

With very few resources, the project started on a selective basis thereby guaranteeing a good success rate but creating a digital divide. Subsequently, the state and some private schools invested into more equipment and more trained teachers became available, thereby bridging some of the digital gap. Next year universal access will be offered in primary schools.

Scalability is closely associated with politics, leadership, economy and sustainability. The latter depends on continuous funding, teacher training, educational software, maintenance of hardware, and renewal of hardware, software and people-ware.

Summary

The chapter explained the research approach, defined the population and data collection from the stakeholders, including the community, public and private sectors, school population, sampling frame and data. Then it mapped appropriate methods and
data to be collected to the research questions. It elaborated the research design: methodology, focused interviews and questionnaire-based samples. Also, it described the pilot survey, the instruments to be used and the data analysis to be performed. Finally, it discussed the issues of validity, generalizability of the findings, and the scalability of the research to a nation-wide program of ICT in education.

The study focuses on secondary schools. A sample of 10 out of 129 schools was drawn and stratified by type according to state, confessional and private schools (37 out of 42 private schools did not have computer laboratories in the year 2000), by region – urban and rural, and by gender for students only. The sample size of participants who received questionnaires is 300 and breaks down as follows: 112 students (50 boys and 52 girls), 40 teachers, 8 rectors/principals/managers, 8 from the administrative staff, and 30 parents. Also, there were three types of focused interviews, namely a group of 20 experts, 2 Principal Education Officers (1 from state inspectorate and 1 from Private Secondary Authority inspectorate), 2 from rectors/principals/managers with no computer laboratory. Hence, the total stratified random sample size was 222. A pilot study illuminated the actual problems of fieldwork as well as the inadequacies of the instruments. The revised questionnaires were used in the actual survey. In free form focused interviews, the questionnaires were filled out immediately after. The data are analyzed and, according to the Ethnographic Delphi Futures Research methodology, results were presented to the panel of 20 experts in three rounds of feedback until there was consensus over most of the goals and strategies proposed. The very few disputed ones were dropped out. Lastly, the four case studies were analyzed through the classical SWOT analysis, and the new proposed conceptual framework with the contextual
factors and the set of metrics that would be developed in chapter 5. Most of the data are secondary. The primary data will be embedded in the analysis. And the complexity of the study required a variety of methods and tools.
CHAPTER 4

LOOKING AROUND AND INTO THE FUTURE

This chapter presents three country case studies, namely Singapore, England and the United States. First, the countries are aligned on a progression scale of ICT progress and education, socio-economic, cultural, political and technology development. Wherever it is possible, a broader context of ICT will be presented to understand the synergies of development. Rich information from various surveys are presented that will permit an analysis and synthesis in the next chapter.

Introduction

In order to capture the essence of the Information Revolution in space and time, a series of snapshots of “hot things” that are pertinent to the research are taken in one place to give a trend over time, and this is repeated in different places to give the extent over space. Together, the pace and the evolution can be placed on a continuum to assess the progress so far. This is a formidable task and, by necessity, the time period and the range of places have to be limited for the sake of space. The most recently available secondary statistics have been used. Information and Communications Technology (ICT) education in many countries have been examined but, for the restricted scope of this study, the subject has been confined to the following three countries: Singapore, United Kingdom (UK) and United States (US). They form milestones on a continuum of the intensity of progress in ICT education in the context of the Information Revolution.
They also reflect their multi-dimensional development status in terms of socio-economic, political, cultural and technological progress. Singapore is a small island economy that has reversed the isolation and traditional belief of a dependency economy of small island states. Singapore and Taiwan (NICs) have restructured their education system, and their children scored among the highest in mathematics, reading and science test (World Education Statistics). Singapore is an advanced newly industrialized country (NIC) that has a successful but different model of education and development from the industrialized nations (G8/OECD), like United Kingdom and United States. The latter two countries initiated and led the Industrial Revolution and have given birth to the Information Revolution. The United States, with its powerful economy, technology, politics, culture and society, is leading again. Mauritius is a recent NIC and can benefit greatly by learning what other progressive countries are doing and intend to do in the field of ICT education. This study will provide a foundation and a framework for the utilization of ICT to transform Mauritius into a developed nation, an information society, a knowledge society, and, eventually, a “values-based” knowledge society.

Scanning the Environment

By looking around and into the future, the environment is scanned for the experience of others, and some threats and opportunities from outside Mauritius. Strong and weak signals of success and failure of past and present initiatives, projects, programs and policies in the three countries are processed. The analysis and the synthesis of the case studies are presented in the next chapter where a lens, in terms of a framework, is developed to examine the case study of Mauritius. The lens will be useful
to analyze other case studies and prescribe a type of appropriate ICT education development.

Case Studies

The case studies that are presented below have been adapted from actual documents and due pointers are set to the authors.

Case 1: Singapore

"Computers are changing the way we work and the way we live... We will use IT to encourage students to learn more independently, to learn actively." PM Goh Chok Tong

![Image](Thinking_Schools_Learning_Nation.png)

Figure 4.1 Tong Illustration

This case study looks first at the country’s vision, the mission of Singapore Education Service, the broad context of IT and human capital, and the IT Master Plan and ICT in schools.

Singapore envisions a high-tech society, with every home, office and school connected with information technology. Every child will be discerning and astute users of information as well as creators of knowledge because this century will witness the increasing use of information and knowledge as engines of productivity and economic growth (moe.edu.sg, February 20, 2002).
A strong IT industry benefits from government support for infrastructure and incentives, and from private sector investment and strategic alliances with international partners. Consequently, government, industry and business support IT education at the tertiary level as well as in schools. This strategic compact yields collective competitiveness or synergy. The job market is excellent, productivity is high and the economy is very good.

The mission of the Education Service is to mold the future of the nation, by molding the people to determine the future of the nation. The service will provide our nation with a balanced education, develop their full potential, and nurture them into good citizens, conscious of responsibilities to family, society and country. People are our most precious resource (moe.edu.sg, March 3, 2002).

**IT and Human Capital**

There are about four million people on a small island of size 6200 sq. kms. There are four official languages: Chinese, Malay and Tamil and English, each with a different script. The language of business is English, which is the universal language of information technology. By 1990, Singapore has a high literacy rate (people who are fifteen years and older that can read and write) of 89% with a breakdown by gender literacy rate of 95% males and 83 % females. In 1994, the World Competitiveness Report ranked the country number one in computer literacy and for its educational system that has provided the skills needed for a competitive economy (gurukul.ucc.American.edu, November 14, 2001).
Higher education is characterized in terms of its two vibrant universities and four polytechnics that provide generalist IT training, and of its advanced research institutes and organizations. In 1994, the output was 2,000 new IT professionals each year. The work force was rated the best in Asia with Hong Kong and the Philippines following behind. There were 4.11 software professionals per 1,000 people, compared to 7.88 in Japan and 7.93 in the US. By 2000, the number of IT professionals would reach 35,000. In 1992, there were over 200 research and development (R&D) IT engineers and technicians per 10,000 people. Six research institutions work in IT (R&D) in the areas of telecommunications, computer integrated manufacturing, software engineering, intelligent systems, wireless computing, parallel processing and digital media in mainly the Singapore Science Park. The country cashed in from its experience by being involved in setting up regional industrial and technological parks in Indonesia, China and India (gurukul.ucc.American.edu, November 14, 2001).

It holds the major market for sound cards.

The government IT 2000 plan aimed at developing, through public and private entrepreneurship, a well integrated and extensive national information infrastructure (NII) based on advanced technology. It comprised seven building blocks: IT manpower, IT culture, information and communication infrastructure, IT applications, IT industry, climate for creativity and entrepreneurship, and coordination and cooperation. To encourage investments, the government offered a package of fiscal and financial incentives in the form of pioneer company status, tax breaks to employee training and partnerships to share start-up costs and risks, and open door policy that allows 100% foreign ownership. Also, many areas, such as the Internet, telecom services and cellular
communications, and telecommunications market, have been deregulated or liberalized to increase competition and innovativeness.

Piracy of intellectual property is a huge problem in the Far East. In 1993, the piracy rate in Singapore was 63% (equivalent to a loss of US$32 million) compared to 94% in China, 98% in Malaysia, and 35% in United States. The country has reinforced its legal environment regarding IT through the Copyright Act of 1987 that protects computer programs as literacy works (gurukul.ucc.American.edu, November 14, 2001).

Singapore has its weaknesses also. As a small successful country, it depends on an export market for its products and services (203% of its GDP in 1991), thereby exposing itself to any sluggish economy worldwide. Due to its high literacy rate, labor costs continue to rise, and companies tend to move to nearby lower cost area such as China, Malaysia, and Indonesia. But the country still attracts high-tech investors from abroad because of the skilled labor and relatively lower labor costs than in developed countries (gurukul.ucc.American.edu, November 14, 2001).

However, small size can be an advantage in deploying IT in education.

Schools

The part is adapted from Internet for Education by Yap Kwang Tan, Educational Technology Division, Ministry of Education, Singapore. Singapore is a small independent republic with 361 schools, a student enrolment of 489,900 and a teaching force of 22,000 teachers. The breakdown, according to type of schools, is as follows in Table 4.1:
Table 4.1  
Enrolment in Singaporean Schools by Level

<table>
<thead>
<tr>
<th>Level</th>
<th>No. of schools</th>
<th>Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>193</td>
<td>280100</td>
</tr>
<tr>
<td>Secondary</td>
<td>147</td>
<td>187400</td>
</tr>
<tr>
<td>Pre-university</td>
<td>18</td>
<td>22400</td>
</tr>
</tbody>
</table>


The average school size was large, being 1451, 1275 and 1244 students for primary, secondary and pre-university, respectively.

In 1994, the Internet was first introduced into schools in Singapore, with 10 computers that were connected to the Internet. Initially, access to the Internet was confined to, as it was important for teachers to be familiar with it first. Subsequently, schools were provided with a number of email accounts for pupils to use in collaborative projects. Today, all teachers in Singapore have access to the Internet, both at school as well as from home. A few schools have provided email accounts to all students through Internet Service Providers (Tan, 1998).

The Master Plan

The mission of the Master Plan for IT is to exploit the full potential of IT to ensure that we educate our children to be among the best in the world. It supports the mission of the Singapore Education Service.

The Master Plan for IT in Education was launched in 1997 has provided:

- a blueprint for the use of IT in schools
- access to an IT-enriched school environment for every child.
It is integral to innovation in the education system to meet the challenges of the 21st century (moe.edu.sg, March 3, 2000). We will use IT to help equip our young with learning skills, creative thinking skills and communication skills. This is a key strategy for producing a workforce of excellence for the future. The plan also seeks to provide a broader base of access to IT among our young so as to achieve a leveling through an IT-enriched curriculum and school environment. The plan is governed by four overarching goals.

**Goals of the Master Plan.** Enhance linkages between the school and the world around it. Teachers and pupils will communicate and collaborate with other institutions, enabling them to acquire richer perspectives in an increasingly borderless world.

1. Generate innovative processes in education. Development of new teaching and learning strategies will open new possibilities for curricula and assessment. Schools will be given autonomy to deploy IT resources flexibly. New school designs will seek to maximize the potential of IT in education.

2. Enhance creative thinking, lifelong learning and social responsibility. IT-based learning strategies will help to develop pupils' ability to think flexibly and innovatively, to co-operate with one another and to make sound value-base judgments.

3. Promote administrative and management excellence in the education system. IT will be used to promote greater efficiency in administration and communication, thereby supporting more effective educational management.
Key Dimensions. There are four key dimensions to the Master Plan:

1. Curriculum and Assessment. Shift towards better balance between acquisition of factual knowledge and mastery of concepts and skills.
Encourage pupils to engage in more active & independent learning.
Include assessment modes that will measure abilities in applying information, thinking and communicating.

2. Learning Resources. Acquire and stimulate development of wide range of educational software to meet curriculum needs. Facilitate use of relevant Internet resources for teaching and learning. Provide a system of convenient (integrated) procurement to help schools obtain software easily and on time.

3. Teacher Development. Use a four-tier fan model for training to generate multiplier effects. Train every teacher in purposeful use of IT for teaching.
Equip trainee teachers with core skills in teaching with IT. Support each school with a full-time Technology Assistant for on-site support and a central help-desk for second level specialist support, and with a few trainers and mentors.

4. Involve institutions of higher learning & industry partners in schools.

Physical and Technological Infrastructure. Provide pupil-computer ratio of 2:1. Provide pupils with access to IT in all learning areas in the school
Provide teacher-computer ratio of 2:1. Provide school-wide network & link all schools through Wide Area Network - eventually connected to Singapore ONE, enabling high speed delivery of multimedia services on island-wide basis.
Administration. The plan seeks to use IT to promote excellence in administration. It will enhance the flow of information within schools and across the system to support effective decision-making. It would also allow the public to access information and transact with MOE and schools from their homes or offices, or through public kiosks.

Resources. The government commits S$2 billion from 1997 to 2002 to implement the above program, which includes funds for computers, full networking of schools, physical renovations, software and courseware, and teacher training. An additional S$600 million a year will be provided to maintain and replace hardware, develop new software, and for the continuous training of teachers. Private sector will participate as suppliers of hardware, as content providers and introduce new technology and ideas (moe.edu.sg, February 20, 2002).

The Ministry is guided by an Advisory Council on IT in Education, which comprises local and overseas experts who advise on the implementation of the Master Plan.

Other. In mid-1995, the project “Accelerating the Use of IT in Primary Schools” started in 6 primary schools. It introduced multimedia teaching in key subjects and pupils spent 10% of the curriculum using IT. In early 1997, the project rolled out to all primary schools.

In 1996, the project “Student’s and Teacher’s Workbench” started in 6 pilot secondary schools with a fully IT-based curriculum in Sec 1 (first year) and pupils spent 30% of curriculum time. The project was extended to all secondary schools. It provided a central repository of educational resources and lessons packages for teachers and has
evolved to the Digital Media Repositories, and the private sector is involved as content providers in the project.

There are 10 primary and 10 secondary demonstration schools that enable experimentation at the frontiers of IT-based learning. They provide the rest of the school system with concrete, local models of innovation in teaching and learning strategies and in school administration.

Schools are given autonomy in implementing their IT program so as to ensure that schools that are advanced in the use of IT will be able to proceed at a faster pace. They can choose different strategies for phasing in the acquisition of IT resources and to take advantage of newer technologies.

Evaluation forms an integral part of the Master Plan. It serves as a systematic means of providing feedback on the implementation of the plan so that appropriate and timely improvements can be made about problem resolution and prevention, innovative practices, and continuous pedagogical improvements.

The Ministry has created an Educational Technology Division, which spearheads the implementation and coordinates the efforts of other divisions, and works in partnership with the tertiary institutions and the National Computer Board.

Implementation Milestones

The implementation of milestones over time is summarized in Table 4.2 below.

The Internet is used for three main purposes in Singapore schools: communication, access to information and collaborative projects.
Table 4.2

Implementation Milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>2:1 pupil-computer ratio in schools with 30% IT-based curriculum time</td>
</tr>
<tr>
<td>2000</td>
<td>Core training for teachers in every school will be completed</td>
</tr>
<tr>
<td>1999</td>
<td>About 250 (Phase 3) schools to come on-stream</td>
</tr>
<tr>
<td>1998</td>
<td>About 90 (Phase 2) schools to come on-stream</td>
</tr>
<tr>
<td>1997</td>
<td>22 (Phase 1) Demonstration schools to integrate IT into curriculum</td>
</tr>
</tbody>
</table>

**Communication.** One of the major goals of the Master plan for IT in education is to enhance linkages between schools and the world around it. This can be achieved through the use of the World Wide Web and email. Many schools in Singapore already have their own website to provide information about the school to parents and the community. The Ministry of Education also uses the Internet to communicate information to schools, as well as providing a platform for teachers to share ideas. Information and services for the public are also made available on the Internet (moe.edu.sg, February 20, 2002).

**Access to Information.** Pupils and teachers use the Internet to access a wide range of information. This is used for teaching and learning as well as in project work. For example, pupils who are studying the environment will source for information from the Internet. For teachers, the Internet is a good source of ideas for lesson activities as
well as primary sources of data. Lesson activities are designed to develop information literacy skills among pupils.

**Collaborative Projects.** With email and the Internet, the scope for collaborative projects between pupils in different schools and different countries has increased significantly. Collaborative projects via the Internet widen the scope of learning for pupils. Pupils could explore different topics of interest with pupils from all over the world. They learn to share and exchange their ideas and, in the process, learn communication skills and how to work cooperatively. Projects involving pupils in different countries also allow them to learn about other cultures and to see themselves as part of the world community. In the last 2 years, pupils in Singapore have participated in numerous collaborative projects with their counterparts in other countries. Some of the initiatives include:

(a) Singapore-United Kingdom Collaborative Project. This project started off in 1997 in which pupils in 2 schools in Singapore collaborated with pupils in 2 schools in the United Kingdom in a project involving a British aircraft carrier, which was sailing from England to Hong Kong. In this project, pupils were able to email one another and with the crew of the aircraft carrier on a range of topics, including technology on the aircraft carrier and the role of women in the navy. When the aircraft carrier stopped in Singapore, pupils went aboard the ship and shared their findings with the crew. Now the spirit of this project continues in a variety of other projects involving 33 schools in Singapore collaborating with 33 schools in the United Kingdom (geocities.com, July 19, 2001).
(b) Project Everest. In conjunction with Singapore's first expedition to Mount Everest, the Ministry of Education organized a project to encourage pupils conduct inter-disciplinary studies, ranging from challenges of climbing mountains to the geology of Mount Everest. Forty-two Singapore schools and 2 schools in England participated in this project. Pupils were able to email members of the expedition and asked them questions related to their climb (moe.edu.sg, July 18, 2001).

(c) ThinkQuest. ThinkQuest is an initiative to encourage collaboration among pupils in different countries to produce educational resources on the Internet. This year, about 300 pupils from Singapore are participating in this project (advanced.org, July 19, 2001)

(d) Konet World Global Environmental Projects. Sponsored by NTT and supported by the Ministry of Education of Japan, Konet World (kodomo network), involves the study of the level of nitrogen oxide in the air around schools. Pupils in Singapore and other parts of the world were provided with simple kits to measure the level of nitrogen oxide. The results were emailed to Japan and the data plotted on a map of Singapore to show the nitrogen oxide levels in different parts of the island (wnn.or.jp, July 19, 2001).

(e) SEAMEO IT Project. Singapore, along with other Southeast Asian countries, belongs to the Southeast Asia Ministers of Education Organization (SEAMEO). The SEAMEO IT project involves pupils in Malaysia, Indonesia, Thailand, Brunei and the Philippines exchanging information on transportation issues and publishing the findings on a webpage (tintin.iti.gov.sg, July 19, 2001).
(f) ScienceAlive. ScienceAlive is a project that allows pupils from different schools to work together on virtual science exhibits. Pupils hold virtual meetings and have on-line discussions with experts. In 1997, pupils built a Virtual Science Theme Park. This year, the project has been expanded to include pupils from Japan (moe.edu.sg, July 19, 2001).

**Future Plans.** As more and more schools go online, the use of the Internet will expand significantly. Some of the possible directions include:

- use of Internet to deliver lessons
- the creation of virtual learning communities
- on-line courses for teachers
- video-conferencing
- Singapore looks forward to collaborating with schools in other countries in the use of Internet for education.

**Case 2: England**

This case refers to a few reports that highlighted early efforts to train IT teachers and the implications to shift from IT as a subject (teaching about computers) to ICT for teaching and learning with computers. Also, it refers to two survey reports (below) that capture the recent state of ICT education in England, and a discussion of the policy, infrastructure, online contents and telecommunications in the context of the present educational program through the National Grid for Learning (NGfL). The general access and use of ICT, in particular the Internet, are reflected in the benchmark survey report (dfee.gov.uk, November 18, 2001), and the situation in schools are in the ICT
survey in schools in England 1998 -2001 (dfee.gov.uk, November 18, 2001). In the context of ICT education, it is important to assess the penetration and usage of ICT devices, mainly the telephone, the computer and the Internet in the households and business. The school is connected to the Internet via telephone lines. The school is reaching out to parents to participate in their children’s schoolwork, and to the community and business for support and sharing of their resources. In the early 1980s, Information Technology (IT) was serviced as an optional isolated subject/skill. According to Somekh (1992), shifting to an integral part of teaching and learning has required considerable staff and institutional development for teacher education. Some strategies ranged from training in-service teachers, developing software and curriculum materials, setting up regional centers for resources and expertise, and part funding for equipment from the government. The benefits envisaged had been limited by institutional and other constraints. Good practice using IT to enhance teaching and learning remains patchy in UK schools (Davis, 1992, p.125). Brown (1993) pointed out several factors that affected in-service teacher education: initial enthusiasm waned off because much more time, effort and responsibilities were required. Teachers and institutions need to own process of change, staff development needs to be increasingly diversified and the teachers themselves need to engage in the search for ways in which IT can enhance teaching and learning. Afterwards, “pre-service teacher education was required to prepare teachers to use IT resources and communications with confidence and competence, to teach the National Curriculum which includes IT as a cross-curricula theme and as an attainment target” (Davis, 1992, p.125). Some student teachers, with support from their university, assisted practicing teachers to implement
curriculum and institutional development. Now IT has improved support from universities to students in schools. Campus 2000 system provides Telecom Gold electronic mail, some databases and computer conferencing. Joint Academic Network (JANET) and wideband SuperJanet provide national electronic links between universities and other services.

General ICT Access, Use and Digital Divide

The growing market of mobile phones, notebook computers and the Internet impacts communications in the school population and others with respect to access to and delivery of educational materials.

As of August 2000, ICT usage in England is shown in Table 4.3.

Table 4.3
ICT Usage in England

<table>
<thead>
<tr>
<th>Device</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Phone</td>
<td>63</td>
</tr>
<tr>
<td>Personal Computer</td>
<td>48</td>
</tr>
<tr>
<td>CD ROM</td>
<td>39</td>
</tr>
<tr>
<td>Internet</td>
<td>37</td>
</tr>
<tr>
<td>WAP Phone</td>
<td>2</td>
</tr>
<tr>
<td>Internet via WAP Phone</td>
<td>2</td>
</tr>
</tbody>
</table>

All ICT media show similar patterns of use by gender, age and social grade. The digital divide exists. Men are more likely to use ICT than women – 50% of men claimed to have used the Internet compared to 40% of women. Higher social grades use Internet more often – 68% of ABs to 22% of DEs, and 61% of prosperous professionals to 25% of Council Estate High Employment group. (A = Upper middle class; B =
middle class; C1 = lower middle class; C2 = skilled working class; D = working class; and E = group in lowest level of subsistence). Usage of ICT (excluding mobile phones) is relatively low for lone parents (36%), people who have difficulty with basic skills (32%) and disabled groups (28%). About 95% of the people are aware of personal computers and the Internet. And 44% claim to have used the Internet at some time.

The perceived value of computer skills is high. Over 80% feel that computer skills are "fairly important" or "very important" for life in general and 44% say that they are "very important". The differences in the digital divide are less marked: 46% of affluent executives expressed that computer skills are "very important" compared to 38% of those in greatest hardship. For employability, 60% believe that computer skills will be essential to get a new job, 44% say they are important now. Only 18% of those aged 55 and older felt so. General usage of computers varies as follows: 85% use a computer at least once a week and 55% use it daily (of which 67% are ABs); 54% of affluent executives do so daily compared to 46% of hardship group. As to duration, those aged 25 – 34 on average use computers for 16 hours compared to 8 hours by those aged 55 and over. Eighty percent use computers at home; half use them at work.

Among non-users, 28% say that they are interested in buying a computer in the future, and the main reason for not using one is the cost. Among non-users who are not interested in future use, 53% say that the idea does not appeal and 32% feel that they are too old. Just under 50% of young non-users aged 16-34 do not afford a computer compared to 21% of those aged 55 and older.

Patterns of use of the Internet are consistent with those of using computers. Thirty seven percent use the Internet, of whom, seventy five percent use it at least once
a week. The least frequent users are C2 and DEs and those who are 55 years and older. The average duration of use during the last seven days is 5.4 hours varying among different age and social grade. By age, the greatest users are among 25-34 years old (6.3 hours) and least among those aged 55 and older (3.8%); and the ABs social grade are the heaviest users (6.1 hours). Users in the deprived areas have low access but those with access spend on average 7 hours in the surveyed week.

The main use of the Internet is to send and receive emails (70%), to obtain information for work (45%); younger people (16-24) for study and learning (51%) and for schoolwork (55%); and older groups use it for work and emails.

Thirty percent of non-users are fairly interested in the Internet for future use, and half of them do not own a computer. Others cannot afford it or they are disinterested in it because the idea does not appeal to them or they are too old.

ICT Access at School, at Home and in the Community

The following illustrates the penetration of ICT in households with children aged 5-18 years. Seventy eight percent of households have a personal or laptop. This increases with the age of the child and is low among those in the social grades D and E (59%) relative to other social grades. Sixty four percent of young (5-18) people’s households have access to the Internet at home and only 45% used it there. The patterns of access are similar to that for ownership of computers. Ninety-nine percent of children have used computers at home, at school or elsewhere, and 23% of those who use them at school do not use them at home. This group comes mainly from social grades D and E and those in Key Stage 1 (5-7) years old or 1-2 school years. Seventy three percent of
children use Internet at home, school or elsewhere (at a friend or relative’s house or at a library). Older children access the Internet outside school for gathering information for schoolwork; send/receive e-mails and collate information for study/learning. Some parents do not buy computers because of the cost (for social grades D and E).

Attitudes of children and their parents towards computers are positive. Both groups perceive that using computers is enjoyable or enjoyable for their children (80%, 85%) and that they allow children to be more creative (81%, 74%). As with computer usage, the range and sophistication of uses increase by school year, and for social grade D and E, the children use the Internet for a narrower range of purposes. Children in Key Stages 1 and 2 (aged 7-11 or school year 3-6 years) mostly play games on their computers at home; for those in Key Stage 3 (aged 11-14 or school year 7-9) and above, they use the computer for doing their homework. At school, children in Key Stages 1 and 2 mainly draw pictures and play games. Among older children, the main computer-based activities at school are related to writing reports, Internet access and analyzing data.

The trend in ICT adoption at the triad (primary, secondary and special schools) for the period 1998 to 2001 are shown in Appendix 7 and the main findings of the survey for 2001 are shown in Appendix 8. Briefly, computer ratio per school for primary, secondary and special schools is (13, 101, 19); Internet access at school is (17, 83, 31) percent; average expenditure per pupil for teaching and learning is (11, 38, 73) pounds sterling and for administration is (4, 8, 18) pounds sterling; teachers and pupils with personal e-mails are (1.7, 8.8, 2) and (0.2, 2.7, < 1) percent; teaching staff who
receive some training are (90, 85, 89) percent; and teaching staff who feel confident in using IT in the curriculum are (65, 61, 63) percent.

The National Grid for Learning

An early initiative to computer education was the Microelectronics, which has a bias towards electronics. A well-designed national program mandated by Parliament and implemented in all schools subsequently replaced it. It specifies the syllabus for each class from primary to secondary and emphasizes the integration of the computer as a tool across curricula in addition to Computer Studies and Computer Science at the General Certificate of Education at the ordinary and advanced levels. More recently, the UK has developed one of the most comprehensive educational networks in the world, the National Grid for Learning.

Policy. In one sweep, the Government is integrating all schools; all institutions of higher learning and lifelong learning, libraries, communities and professionals into the NGfL. Public and private sectors, and students, teachers, parents and communities collaborate to develop this mega network. There are various sources of funding and initiatives and leverages that the Government uses to balance market forces to offset disparities.

In 1998, in a challenging document, Open for Learning, Open for Business, NGfL set out the challenges to learners, education and industry and set its targets for 2002 as follows:

- Connecting all schools, colleges, universities and libraries and as many community centers as possible to the Grid.
• Ensuring that serving teachers feel confident and are competent to teach using ICT (Information and Communication Technology) within the curriculum; and that librarians are properly trained.

• Enabling school leavers to have a good understanding of ICT, with measures in place for assessing their competence in it.

• Ensuring that general administrative communications between education bodies and the government and its agencies cease to be largely paper-based.

• Making Britain a center of excellence in the development of networked software content, and a world leader in the export of learning services.

**Access.** By August 31st 2002, in order to be eligible for NGfL 2001-02 grants, the LEAs (Local Education Authorities) have a commitment to achieve the baseline in all schools:

- a pupil to computer ratio of at least 11:1 in each primary school and 7:1 in each secondary school.

- a connection to the internet in each school, with at least 20% of schools connected at broadband level.

- at least one networked computer with Internet access in each school for management and administrative purposes.

The Government wants everyone regardless of age to be able to benefit from the Grid. It is possible to publish one’s own learning material on the Grid and help other learners, and consult the career advisor online.

The Government fully recognizes the importance of preserving choice in the way in which schools and other learning institutions procure ICT, so long as the method
chosen represents good value for money. The Government is also determined to encourage new models of supply, which free teachers and others to concentrate on their professional priorities.

**Infrastructure.** The National Grid for Learning (NGfL) is both a structure of educationally valuable content on the Internet, and a program for developing the means to access that content in schools, libraries, colleges, universities, workplaces, homes and elsewhere. Its content will soon be also accessible through the television set as we cross the threshold of the information age with the arrival of digital interactive broadcasting.

As architecture of content, it provides links to information, advice and learning resources. Tailored facilities exist for each of the home countries of the United Kingdom. For schools in England, the Grid contains the Standards Site, the Virtual Teacher Centre, Governor Centre, and Parent Centre. It will soon link to the Public Library Network, the University for Industry and the Learning Direct help-line, and to a growing number of Community Grids for Learning with information about learning services in a given area. Over the next year or so the Government will be encouraging the development of further exciting, dynamic facilities including the GridClub, an interactive facility for young learners combining broadcasting, the Internet and other powerful learning resources which will be fun to use and help young people to succeed in homework, examinations or simply discover more about the world.

As a program to develop the content and the means to access it, the Government aims to stimulate significant growth in the amount and quality of educational software, and on-line and broadcast content available to learners. The Government’s challenge to industry aims to lever change in three main areas:
Contents. The development of high quality learning software, broadcast programming and on-line content is essential to the success of the initiative. One of the key goals of the Grid is to provide a means of identifying and accessing content, which is relevant and differentiated according to the needs of users. It will provide a significant incentive to content developers. However, it will not be sufficient in itself to generate the necessary diversity and quality of learning content. The four UK countries will therefore pursue a variety of strategies tailored to local needs and funding mechanisms; for example, in England the Government will earmark resources within the Standards Fund NGfL program for content purchase by schools, and to support the development of content by schools and learners themselves. This will complement the £50m being made available through the New Opportunities Fund for the digitization of content in libraries and other public institutions such as museums and galleries. BECTA (British Educational Communications and Technology Agency) will also help safeguard the copyright and intellectual property rights of content developers through clear and readily available advice to Grid users, and a code of conduct for content providers. GridWatch, a facility to be set up through BECTA, will enable action to be taken to exclude inappropriate materials from the Grid and guard against infringement of copyright. These measures will form the basis of an educational software and content strategy, which the Government will implement over the next two years in conjunction with relevant industry representative groups.
• Telecommunications. A high priority for the Government over the next five years will be to increase the availability of fast-speed (broadband) connections for schools and other institutions according to their needs. As a first step, BECTA and Oftel will review the progress made in connecting schools to medium speed lines (ISDN2 – Integrated Services Digital Network), and report on the implications for schools and other institutions. Oftel will consider the scope for predictable and affordable tariff arrangements for libraries, FE (Further Education) and sixth form colleges. In addition the Government and Oftel will be considering carefully with the telecommunications industry the prospects for public services as a whole, including the prospects in respect of high-speed services and of tariffs for learners, irrespective of their location. The Government will look to the telecommunications industry to respond positively given the significant increase in on-line business resulting from the NGfL initiative.

• Supporting services. This Challenge specifically calls for proposals from industry for a new model of supplying ICT to education and learning institutions. This should result in the availability next year of competing managed services supplying, maintaining and renewing packaged ICT networks. These will range from the smallest, four linked terminals, to networks of up to 500 terminals in the largest institutions, with speed of connection related to the size of the network and its use. BECTA will test and certificate all managed services, which meet a minimum standard, whether supply is proposed on a nationwide, regional or local basis. From next year schools, education
authorities and other institutions should be able to meet the costs of these services on a fully predictable lease or installment basis, and have the right to change to another managed service if contracts are not properly fulfilled. They will be free, however, to use other procurement strategies, such as purchasing ICT on an item-by-item basis, should they wish. Additionally industry may wish to develop affordable home learning centers, which would be available to pupils and other learners at home. These would be certificated by BECTA as fully compatible with the Grid and of a guaranteed minimum standard.

The Grid will provide all institutions and agencies delivering and promoting learning with new opportunities to offer better services, closely tailored to the needs of learners, collectively and individually. Particularly important will be the development of content for community grids for learning, linking education, library, health, leisure and other services at local, metropolitan or regional level. Managers of learning institutions, advisers, teachers, lecturers, librarians, museum and gallery staff, and administrators all have a part to play.

The Government aims to see a tripling of the market in educational ICT by 2002 as an incentive to industry to develop such services, and to stimulate significant growth in the amount and quality of educational software and on-line and broadcast content available to learners. The Government's challenge to industry aims to lever change in three main areas: helping the student to relate homework to school resources, use the library to research the required material, and participate in the interactive GridClub.
Case 3: United States

"Every child in America deserves a 21st century education and access to 21st century technology" - Vice President Al Gore (ed.gov, February 20, 2002b, p. 9).

This debate has never been about technology. It has been about what our children have the opportunity to do. It's about much more than just giving a young person a computer or connecting that person to the Internet. It's about connecting students to a whole new world of learning resources and offering the mind the opportunity to expand and take on a new and challenging future. (Secretary Richard W. Riley, U.S. Department of Education; ed.gov, February 20, 2000a, p. 33)

The organization of school will be difficult to change. Ultimately, we need to think about new ways of assessing and documenting competence, much of which may be supported by technology in order to free up educational organizations and structures to try new methods to meet the goals of education. This will be a technology-based, more far-ranging version of the current exchange of flexibility for accountability seen in charter schools. (Participant, Forum on Technology in Education: Envisioning the Future; ed.gov, February 20, 2000a, p. 53)

Introduction

This case study describes a wider setting of the impact of ICT: the diffusion rate of some main technologies, communications, the economy, job market, productivity, access to computers and the Internet at home and in schools, the digital divide, the teenage perception, teacher training, and the federal and Massachusetts educational technology plans. The Information Revolution is best captured in the United States and some related events and trend statistics of the eighties and mostly the nineties are included. Wherever it is possible, the most recent statistics available to the author at the time of writing are included. Also, the statistics are quoted from a multitude of sources, and consequently, the snapshots in time and space remain patchy.
There are large variations in ICT adoption in schools for teaching and learning across the United States. We focus on Massachusetts to capture the landscape of ICT in education.

**Diffusion Rate of Technological Breakthroughs.** Jean Claude de Ravel, the chief editor of a major French newspaper Le Monde, wrote in *The Next Revolution: Neither Jesus nor Marx* about the following: if there will be a cultural revolution it will certainly be in the United States. It is equally true that the country has been the birthplace of many technological revolutions.

New technologies are reaching the US population faster than ever. The diffusion rate of new technologies is listed below in Table 4.4.

**Table 4.4**  

<table>
<thead>
<tr>
<th>Date</th>
<th>Invention</th>
<th>Years till mass use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1873</td>
<td>Electricity</td>
<td>46</td>
</tr>
<tr>
<td>1876</td>
<td>Telephone</td>
<td>35</td>
</tr>
<tr>
<td>1886</td>
<td>Gas Automobile</td>
<td>55</td>
</tr>
<tr>
<td>1906</td>
<td>Radio</td>
<td>22</td>
</tr>
<tr>
<td>1926</td>
<td>Television</td>
<td>26</td>
</tr>
<tr>
<td>1953</td>
<td>Microwave Oven</td>
<td>30</td>
</tr>
<tr>
<td>1975</td>
<td>PC</td>
<td>16</td>
</tr>
<tr>
<td>1983</td>
<td>Mobile Phone</td>
<td>13</td>
</tr>
<tr>
<td>1991</td>
<td>The Web</td>
<td>7</td>
</tr>
</tbody>
</table>


Clearly, there is a culture of technology innovations and evolution. The diffusion rate to mass use is getting ever shorter.

**Communications.** In 1995, the telephone penetration rate in the United States was 552 per 1000 people for a population of 252.5 millions. The country spent 2.8 percent of its GDP on IT (Dedrick, Goodman, & Kraemer, 1995).
One hundred million Americans use mobile phones, and tens of thousands of new customers wire up everyday” (Kalb & Springen, 2000). In fact, other nations have much higher mobile phone access rate, e.g., virtually 100 percent of Finnish young people aged 14 to 21 have mobile phones. Half of their use is for Short Message Systems (SMS) calls, i.e., short messages of up to 160 characters, and the average Finnish teenager swaps about a hundred SMS messages monthly and the volume is growing.” (Kari, 1999).

Nearly half of all American households now use the Internet, with more than 700 new households being connected every hour (whitehouse.gov, October 5, 2001). Some analysts believe that significant further market penetration is likely even among low-income under $25,000 families since 70% have cabled access at home. Internet-ready computers, other alternative devices, “Internet appliances”, handheld devices, other wireless technologies, and soon digital television and “set-top” boxes will make online access more affordable.

IT and the Economy

Across the entire U.S. economy, 58 percent of the total workforce (including government) deals with office work. It is also estimated that 60 percent of the U.S. Gross National Product deals intensively with information. Across the industrial nations of the world, the situation is not much different with the ratio closer to one half” (Dertouzos, 1997). Americans own 149 million e-mail addresses, cellular phones and pagers. Americans left 12 trillion voice messages for each other last year. Sixty percent of our PC’s are now attached to networks, an increase of 500 percent in 5 years (Braun,
In 1990, company purchases of high-tech equipment (computers, communication gear, and instruments) were 20 percent of all investments (from office building to industrial machinery). By 1998, it was 40 percent.

In 1989, an estimated 21 million personal computers were sold worldwide, about 9 million of them in the US. In 1998, worldwide PC sales totaled 93 million and US sales were about 36 million. In 1990, about 15 percent of US households owned a computer. Now that’s 50 percent. (Samuelson, 1999)

By contrast, Indians owned only 1.8 million PCs (Strasser & Mazumdar, 1997).

The diffusion rate of PCs in US households is impressive. In 1993 there were 25 millions, in 1994, 33 millions and in 1995, 38 millions (Fax, 1997). Equally is the online rate of American households: 25% of all households in 1997, 33% in 1999 and 52% in 2000 (neweconomyindex.org, December 10, 2001a). A broad range of Americans is getting online. The average age of the Internet users are dropping, as is the average education level, suggesting that the online population is looking more like the American population in general.

The U.S. home personal computer market is the largest in the world, holding a 55 percent share of the $24 billion-a-year global market for home PCs. Thirty-seven percent of U.S. households have one or more PCs, including systems provided by employers or schools, compared with 28 percent Germany; 24 percent in Britain; 15 percent in France; and less than 10 percent in Japan. U.S. consumers spend about 13 hours a week using home PCs; 80 percent of that time is work-related.

Multimedia and CD-ROMs have witnessed an exponential growth. Americans spent $424 million on educational CD-ROMS for their children in 1999 (Tanaka, 2000). Actually, multimedia drives the PC technology. Consequently, there is an exponential
growth in image processing and digital photography. “Around the world, more than 2,700 photographs are taken every second. Vacation pictures take up to 80 percent” (Harks, 1999).

Jobs. Since 1995, more than a third of all economic growth has resulted from IT enterprises. In 2000, more than 13 million Americans hold IT-related jobs, and the rate of growth is six times as fast as overall job growth (whitehouse.gov, October 5, 2001).

190,000 high-tech jobs are now vacant. The Department of Commerce reckons the nation will need a million more information-technology workers by the year 2005 than will be available. Fewer students are graduating with college degrees in computer science and electrical engineering—24,200 in 1994, compared to 42,000 in 1986. A typical programmer earns between $70,000 and $90,000 year, with annual pay hikes trending toward 20 percent. Signing bonuses ranging from $10,000 to $20,000 are not unusual. (Hafner & Meyer, 1997)

In the past decade, the number of jobs requiring computer skills has increased from 25 percent of all jobs in 1983 to 47 percent in 1993. By 2000, 60 percent of the nation’s jobs would demand these skills—and pay an average of 10 to 15 percent more than jobs involving no computer work. (Oppenheimer, 1997)

An educated workforce is critical to increasing productivity and fostering innovation. From 1983 to 1993, knowledge jobs (requiring post secondary, vocational, higher education) had increased from 27% to 31% of total employment, and are expected to grow to 33% in 2006. Metro areas with strong higher education systems (Austin, Raleigh, Boston) tend to attract knowledge workers in order to provide an adequate supply of skill labor, thereby boosting overall incomes that grew by 1.8% in real term per year during the period from 1980 to 1997. Meanwhile metro areas that have invested less in education have a net out-migration (Grand Rapids, St. Louis, Milwaukee) but a higher level of immigration from developing nations (Los Angeles, San Francisco, Miami). Finally, entrepreneurs in IT are more likely to have higher
levels of education, and more knowledge workers increase entrepreneurial activity contributing to the region’s economic success (neweconomyindex.org, December 10, 2001b). So Investing in IT education is rewarding.

However, the bubble burst in the economic downturn. The dot-com companies melted down, thereby sagging the high technology sector and the overall economy. But the potential of the IT industry has been proved.

**Productivity.** In March 2000, the Federal Reserve reported that the use of technology and the production of IT goods since the mid 1990s had accounted for about $50 billion in productivity output every year, contributing over two-thirds of the $70 billion annual productivity gain over the same period. Management policy, business process improvement and technology, such as, collaborative software tools, newer PCs, increased network bandwidth, mobile computing devices and wireless devices, are credited for some of the productivity gains. “In addition to worker output, IT is improving customer service, range of offerings, response time, product quality, and customization of product and services” said Professor Eric Brynjolfsson from the Center for e-Business at MIT’s Sloan School of Management. Experts predict that the Internet will drive the next wave of productivity (McGee, 2000).

**Access**

The average American child spends 900 hours a year in school—and 1,500 hours a year watching television (Alter, 1998). Seventy-two percent of 8 to 12-years-old reported spending time on a PC during the last 30 days, as opposed to 55 percent of 6 to 7-year-olds and 67 percent of teenagers, according to (Gehl and Douglas, 1997). In
2000, the average American child watches screen technologies (television, videogames and computer) 5 hours a day, and uses the computer 34 minutes a day (futureofchildren.org, November 11, 2001). About two-third of the children have access to a computer at home. Among children aged 8-16 years, 20% have computers and 11% have access to Internet in their bedroom (futureofchildren.org, November 11, 2001). Excessive exposure to screen technologies could hamper social development and put children at risk of obesity and depression. More research is needed to assess the effects of extended computer use and exposure to computer content on children’s physical, intellectual, social and psychological development.

Many believe that computers and the Internet can play a key role in improving education. The use of IT in America’s schools is growing. Virtually all schools have computers and have access to the Internet. From 1983 to 1998, the number of computers in American schools had increased dramatically from 250,000 computers to 8.6 million. The ratio of students to computer had been reduced from 123:1 in 1983 to 14:1 in 1994 (Little, 1997) and to 9:1 in 1996. Many of these machines were old, slow and without access to the Internet. In 1994, 35% of all schools were connected to the Internet (at least one connection); in 1997, they were 78% and, in 1999, they were 95%.

US schools that are wired to the Internet are shown below in Table 4.5:
Table 4.5

U.S. Wired Schools to the Internet During 1995-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All schools</td>
<td>50</td>
<td>65</td>
<td>78</td>
</tr>
<tr>
<td>Elementary</td>
<td>46</td>
<td>61</td>
<td>75</td>
</tr>
<tr>
<td>Secondary</td>
<td>65</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>City</td>
<td>47</td>
<td>64</td>
<td>74</td>
</tr>
<tr>
<td>Rural</td>
<td>48</td>
<td>60</td>
<td>79</td>
</tr>
<tr>
<td>Less than 6% minority</td>
<td>52</td>
<td>65</td>
<td>84</td>
</tr>
<tr>
<td>50% or more minority</td>
<td>40</td>
<td>56</td>
<td>63</td>
</tr>
</tbody>
</table>


Poorer schools lag about a year or so behind other schools in adoption rates (futureofchildren.org, November 11, 2001). It is noted that the metro areas, where children were most likely to use computers in schools, are in the older, industrial metros in the Midwest whereas some “high-tech” metros, like San Francisco, Seattle, Boston and Salt Lake City, score much lower. Maybe, political leadership is a determinant.

Among the top twenty States (like Alaska, Washington, Hawaii, Nebraska, Utah, etc.) that are less densely populated (except Delaware) and more geographically dispersed have been farthest ahead in integrating IT into schools than those of densely populated East Coast and Midwest states (New York, New Jersey, Connecticut, Maryland, Michigan and Ohio). The plausible reasons are that these states need better connections to information and resources, and that their political leaders believe that the IT revolution is an important key to their future prosperity and that it is essential to properly train the next generation of workers (neweconomyindex.org, December 10, 2001a). However, putting computers in classrooms is only the first step towards computer education in schools.
Connecting Schools and Home

Datta and Kanter (1998) researched the school-home connections and found that traditionally

- 38 percent of schools require parents to sign their child’s homework;
- 32 percent of sponsor agreements with parents about learning at home;
- 22 percent assign homework that requires parent involvement, and using print and telecommunications;
- 75 percent of parents get school newsletters;
- 72 percent get phone calls from teachers and administrators; and
- e-mail, websites, and cable TV reach fewer than one parent in four.

ICT can facilitate communications and bring school closer to home or involve parents closer into the work of their children at school. Performance can be monitored every day or week; the lessons of the day and those of the next day or week can be made available on the web. “The exponential benefits to students do not usually occur until home use is integrated into the curriculum,” observed Carole Cotton of CCA Research. The school accounts for 30 percent of children’s achievement. It is also true that the home, neighborhood, and peer environment account for 70 percent of what children do.

In fact, The National Educational Technology Standards for Students recommended that technology be used to shift education from: teacher-centered to learner-centered instruction, single media to multimedia, single sense to multi-sense, passive learning to active, inquiry-based learning and facts to critical thinking.
Digital Divide

Home access to computers and the Internet varies widely by income. The distribution of PCs by household income (Hall & Visgaitis, 1998) was as follows in Table 4.6:

Table 4.6

<table>
<thead>
<tr>
<th>Income in $</th>
<th>% households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10,000</td>
<td>5</td>
</tr>
<tr>
<td>10,000 - 14,999</td>
<td>20</td>
</tr>
<tr>
<td>15,000 - 24,999</td>
<td>26</td>
</tr>
<tr>
<td>25,000 - 34,999</td>
<td>40</td>
</tr>
<tr>
<td>35,000 - 49,000</td>
<td>55</td>
</tr>
<tr>
<td>50,000 - 74,999</td>
<td>57</td>
</tr>
<tr>
<td>75,000 and up</td>
<td>75</td>
</tr>
</tbody>
</table>


It is noted that the PC ownership at home increases with household income.

In 1994, the U.S. Department of Commerce reported the disparities between ethnic groups, see Table 4.7 (Newsweek, 1995):

Table 4.7

<table>
<thead>
<tr>
<th>Ethnic group</th>
<th>PC Ownership (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian or Pacific Islander</td>
<td>39.0</td>
</tr>
<tr>
<td>White</td>
<td>28.6</td>
</tr>
<tr>
<td>Amer. Indian, Aleut, Eskimo</td>
<td>20.7</td>
</tr>
<tr>
<td>Hispanic</td>
<td>13.1</td>
</tr>
<tr>
<td>Black</td>
<td>11.1</td>
</tr>
</tbody>
</table>

A Newsweek poll revealed “kids from lower income homes used computers as often as kids from wealthier families, but get their access from school more than home. This suggests that wiring schools is an effective way to close the gap between the haves and have-nots. Teens from families earning less than $25,000 a year were twice as likely to say they never used a computer at home. Sixty-one percent “surfed the net”.

“Boys edged out girls in on-line experience (66 to 56 percent) and wealthier kids are more likely to have surfed. Only 14 percent of those who have been online admitted to having seen or done something they would not want to their parents to know about.” Boys were slightly more likely (57 percent) than girls (46 percent) to say technology makes their lives much better (Newsweek, 1997).

While pre-teen computer use is roughly equal for boys and girls, girls were more likely to use computers at school, while boys tended to use them at home.

The Department of Education stated that girls account for only 1 percent of computer science “advanced placement tests taken by high school youths. In colleges, women earn just 28 percent of computer science undergraduate degrees, a sizable drop from pre-internet 1984, when they earn 37 percent.” (entovation.com, February 21, 2002).

It is noted that low-income families tend to use computers less because they lack connection to the Internet. Also they have less access to quality computer programs and have fewer creative uses of the computer. Attempts to close the gap in the digital divide can be broadly categorized: (a) in school access: children without computers at home could have access at school, (b) out of school access: industry could expand opportunities for low-income families to acquire computers and access the Internet, and
(c) public and private funders could support efforts by libraries and community centers to include teaching programs that are focused specifically on children.

Teenage Perception

Teenagers showed familiarity and optimism among frequent computer users and are upbeat about technology’s impact on their lives. Eighty-nine percent of teens use computers at least several times a week. Eight percent credit technology for making a positive difference in their lives. Ninety-two percent think computers will improve their educational opportunities; almost as many think that technology will create better jobs in the future and help us live longer, healthier lives. Twenty-eight percent believe that technology is not helping—or, worse, actually harms—the environment. (Newsweek, April 1997, p. 86)

Teacher Training

The US spent $530 billion on Education in the 1995-96 school year, counting everything from elementary to graduate school. There are 3.1 million teachers in the US. Between 1979 and 1989, average teachers’ salaries (after inflation) rose 20 percent.

The most critical factor in the quality of a child’s learning experiences – with computers or otherwise – is the quality of the child’s teacher. Strategies that focus on teachers’ skills and abilities may be what are most needed to ensure educational success of our nation’s children (futureofchildren, November 11, 2001). Yet, in Massachusetts, applicants for new teaching jobs are being tested for basic competence in reading, writing, and a subject area; fifty-nine percent failed! (Newsweek 1998a, p. 49).

In general, teachers are not comfortable to use technology effectively in their classroom. They lack training and are incapable of adjusting to technological events. Traditional teacher training programs are not up to the par (nces.gov, March 19, 2002;
Morsund & Bielefeldt, 1999). It will not be easy to re-educate existing teachers without professional development that provides the same technology literacy skills required of students.

There is a mismatch between state and district achievement tests and higher-order thinking skills of digital content as per curriculum (Trotter, 1999). It is crucial to have teachers in the classroom who possess the ability to integrate and utilize technology. The U.S. Department of Education has established the grant program “Preparing Tomorrow’s Teachers to use Technology” or PT3 under three types of grants: Capacity building, Implementation and Catalyst for one to three years’ support. Some projects support teachers in integrating technology (see Table 4.8).

Table 4.8
Projects Supporting Teachers in Integrating Technology

<table>
<thead>
<tr>
<th>Project</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Viewing and Doing Technology Project (VDT).</td>
<td><a href="http://www.ci.swt.edu/VDT/VDT.html">http://www.ci.swt.edu/VDT/VDT.html</a></td>
</tr>
<tr>
<td>Integrating New Technologies into the Methods of Education.</td>
<td><a href="http://www.intime.uni.edu">http://www.intime.uni.edu</a></td>
</tr>
<tr>
<td>T QWEST: Technology in Higher Education: Quality Education for Teachers and Students.</td>
<td><a href="http://www.theqwest.state.la.us">http://www.theqwest.state.la.us</a></td>
</tr>
<tr>
<td>Pre-service Infusion of Computer Technology.</td>
<td><a href="http://www.bgsu.edu/colleges/edhd/LPS/EDFI/PICT">http://www.bgsu.edu/colleges/edhd/LPS/EDFI/PICT</a></td>
</tr>
<tr>
<td>Trek 21: Educating Teachers as Agents of Technological Change.</td>
<td><a href="http://www.trek-12.wvu.edu">http://www.trek-12.wvu.edu</a></td>
</tr>
<tr>
<td>Models, Mentors, Mobility: Tomorrow’s Technologically Astute Teachers.</td>
<td><a href="http://education.twsu.edu/m3">http://education.twsu.edu/m3</a></td>
</tr>
</tbody>
</table>

Fortunately, many of the above ideas have a place in the educational technology plans, both the federal and the state (Massachusetts).

**Strategic Technology Plans**

**Federal Educational Technology Plans.** Since the 1960s to the mid-nineties, enterprising individuals, not-for-profit, private and state organizations had embarked on initiatives, projects and programs of computer literacy. They had shown the viability of enhancing the educational experience through ICT for teaching and learning. In 1996, United States released the first national technology plan “Getting America’s Students Ready for the 21st Century: Meeting the Technology Literacy Challenge” (ed.gov, February 20, 2002b), which can be summed up in ex-Vice President Al Gore’s vision “Every child in America deserves a 21st century education and access to 21st century technology”. The plan reflected four goals:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.
- All teachers and students will have access to modern multimedia computers in their classrooms.
- Every classroom will be connected to the information superhighway.
- Effective software and online learning resources will be an integral part of every school’s curriculum.

The plan provided the nation with a blue print for the widespread, effective use of technology in education. There is emerging evidence of effective uses of technology
in education, and there is far reaching public support for the increase use of technology in elementary and secondary education.

In 2001, the Department of Education published its second technology plan “E-learning” (ed.gov, February 20, 2002a). The second plan consolidates the work started under the first plan by defining standards and curricular frameworks, emphasizes the urgent need for research and evaluation, and sets the direction for information literacy.

The goals are:

- All students and teachers will have access to information technology in their classrooms, schools, communities and homes.
- All teachers will use technology effectively to help students achieve high academic standards.
- All students will have technology and information literacy skills.
- Research and evaluation will improve the next generation of technology applications for teaching and learning.
- Digital content and networked applications will transform teaching and learning.

These new goals represent an undated, high-level strategy for ensuring that all students benefit from enhanced learning opportunities afforded by new and emerging communications and information technologies. The new plan reflects a major leadership imperative: the use of technology in education as a national priority and at the core of the educational experience.

Massachusetts Technology Plan 2000. The status of ICT in education varies across states. In order to get a clear picture, we focus on the state of Massachusetts to
get some tangible results. Within the state there are a lot of variations and the state average for a given variable is generally adequate.

Massachusetts Education Reform Act of 1993 brought sweeping changes and expanded the role of information technology in the public schools. From 1993 to 2000, the budget for technology spending ranged from $30 to $200 million a year. The Department of Education (DOE) has promoted the following three goals:

- To enhance learning opportunities for all students;
- To strengthen teachers' professional capabilities; and
- To improve administrative efficiency.

In 1999, the first phase of the Virtual Education Space (VES) was launched as a publicly owned architecture for a K-12 e-learning system to provide a free personalized electronic workspace to every teacher, student and parent (doe.mass.edu, February 13, 2002). Accessible from the computer with a web browser, the network will link teachers, students, and parents with a wide array of educational resources like curriculum, instruction, assessment, including a set of collections of standards-based lesson plans, online courses, and collaborative tools (doe.mass.edu, March 14, 2001).

State and federal resources are available to provide funding and incentives to help districts jumpstart their technology programs. The federal E-rate programs provide substantial savings to schools and libraries on their telecommunications purchases. The Educational Technology Integration Services (ETIS) has helped public schools and libraries procure technology hardware and telecommunications services cost-effectively.
In 2000, the average number of students was 5.6 per high-speed multimedia computer connected to the Internet. The nationwide benchmark was 5:1 student-to-computer ratio. Computers are classified as type A (modern), B or C (old), and their processors are regularly upgraded to new and faster processors to maintain the ratio.

Another benchmark is that every classroom and administrative office has at least one computer with a high-speed connection to the Internet by 2003. The speed and quality of Internet access are critical for streaming video and animated graphics. The trend has been (see Table 4.9).

<table>
<thead>
<tr>
<th></th>
<th>Fall 1997</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internet Access (%)</strong></td>
<td>41</td>
<td>51</td>
<td>69</td>
<td>79</td>
</tr>
<tr>
<td><strong>LAN (%)</strong></td>
<td>46</td>
<td>54</td>
<td>69</td>
<td>78</td>
</tr>
</tbody>
</table>


The types of access in classrooms that are connected to the Internet are 56KFrame Relay (4.25%), Dial-up 1.24%, ISDN (8.43%), T1 (46.34%) and other type (18.52%).

Keeping the computers and networks up and running is crucial to successful technology implementation: The benchmark is one full-time equivalent (FTE) for 100-200 computers, which was based on an estimate of the needs of an average-size school (compared to the business model of 1 support person for every 50-70 users) (whitehouse.gov, October 5, 2001). However, the needs among school districts vary and this has to be taken into consideration. The state average was 372 computers for every support person, and was 319 when all contracted services and others (volunteers,
students, aides, paraprofessionals) were factored in. Technical support is available through the “Students as Technology Leaders”, in which students gain expertise as technical repair specialists and are hired by schools to provide supplementary technical support. (doe.mass.edu, March 14, 2001, p.11)

Many teachers are not ready to use technology in their teaching because they have not had time to explore resources or effective models for using technology in the classroom. To help integrate technology into the curriculum, an expert (staff person with technology and curriculum expertise) collaborates with classroom teachers to help both teachers and students learn technology skills within the context of curriculum activities. The recommended benchmark for the year 2003 is 0.5 FTE (full time equivalent) to support 30-60 users (professional staff) in their efforts to achieve technology competency and to integrate technology into the curriculum. In 1999-2000, the state average was 39.13 staff members supported by 0.5 FTE curriculum specialist. The expert should take care not to merge curriculum integration with technical support, which is very time-consuming (doe.mass.edu, March 14, 2001, p11). There are also a number of state- and federally funded projects that help teachers integrate technology into the curriculum: “Massachusetts Empowering Educators with Technology” (Project MEET – a five-year $10 million initiative sponsored by the federal Technology Innovation Challenge Grant Program) – trains school-based teams of teachers with one team member designated as technology professional development specialist who commits 50% of his or her time to providing support to peers in the district; “The Technology Literacy Challenge Fund” – a five-year $2 billion federal initiative that provides states with funds to support school districts through a competitive process, and
in Massachusetts, this grant is used to focus on catalyzing change in teaching and learning rather than supporting operations; and “Teaching State Standards with Technology” is a competitive state matching grant to school districts and charter schools to adopt replicable practices in using technology to improve student achievement on curriculum aligned with the state standards (doe.mass.edu, March 14, 2001, p. 14). The technology expenditures per student for financial years 1997-2000 were $159.59, $203.18, $230.06 and $276.18, respectively (doe.mass.edu, March 14, 2001, p. 4).

The technology professional development ensures that teachers must know how to use technology. The goal is that, by the year 2003, 85% of the district staff will have participated in technology training sponsored by the district. The state average for 1999-2000 was 56%.

The “Assistive Technology Project” (alternative input: modifications to standard keyboards, touch screen microphones and switches; output methods: speech synthesizers, large print output, refreshable Braille or text-to-text speech; closed caption for video for the deaf and hard-of-hearing students; and universally designed software which accommodates access by all) under the Technology Literacy Challenge Fund grant and Project MEET help school districts and collaboratives learn how to conduct assistive technology assessments and design appropriate classroom environments using a wide array of technologies (doe.mass.edu, March 14, 2001, p. 18). The state results for Fall 2000 were 62% for input and 56% for output methods, 38% for closed caption video, and 74% for universally designed software.
Summary

The chapter presented three cases studies of Mauritius, Singapore, England and the United States aligned on a progression line in terms of ICT and economic development as small islands states, newly industrialized countries and developed countries. Wherever it was possible, the broader context of ICT had been presented because the other factors synergized the ICT education.

The three cases were a rich foray of information from various surveys. They will be analyzed and synthesized in the next chapter.
CHAPTER 5

ANALYSIS, SYNTHESIS AND LENS

Chapter 4 scanned the environment of ICT and ICT education, and focused on three country case studies of ICT that represented a progression on the economic and technological line of development. In this chapter, I stepped back, took some panoramic snapshots, and weaved through them to construct the big picture. Here, I present an analysis of the ICT education within the broader education environment, together with some noteworthy events from elsewhere in the world, and a synthesis of the ideas, which crystallize into a framework that can be used as a lens to examine a country status and requirements for computer education. In particular, the lens will be applied to Mauritius to produce a strategic plan for ICT education in the next chapter.

This chapter is in two parts: Part I deals with the analysis and synthesis, and Part II with the framework.

Part I: Analysis and Synthesis

In this part, I looked at the big picture of industrialized, newly industrialized and some comments on developing countries, even small countries, as well as a few relevant regional activities. Common themes are filtered. Then I focused on the three main case study countries. I performed the classical SWOT (strengths, weaknesses, opportunities and threats) analysis for strategic planning and identified their vision, goals and strategies (Mintzberg & Quinn, 1991).

The next section presents a deeper analysis within the common themes that are identified above. The main issues are discussed. Within a theme, there is a country
comparison, wherever it has been possible to do so, which is followed by an abstraction that deals with the philosophies, policies, and best practice.

Secondary data are embedded and interpreted with the text. Some important metrics are proposed. The refined version is presented in the case study of Mauritius to avoid repetition.

The Big Picture

In the wake of the post-industrial evolution and the dawn of the information revolution, industrialized (G8/OECD – Organization for Economic Cooperation and Development), middle-income, newly industrialized, some developing countries, and some small state economies, have made plans for Information and Computer Education (ICT), and many have implemented them, for developing human capital towards producing and/or using information services, and information products. In some NICs, the government has interfered with market forces to create the right balance for education and development, and they have leapfrogged to the forefront (Ashton, Green, James, Sung, 1999). Small states adopt ICT education in an attempt to connect themselves with the rest of the world and for development. The common thread is the unifying computer language, which is English with a great cultural impact. In the knowledge society, there will be a vast potential for the creation of wealth, power, control, cultural push, etc. All computer users who can access the Internet can communicate and engage in e-business, e-education and e-governance. There is a pressing need for user-friendly cheaper computer systems of hardware, software and “peopleware”.
The paradigm is pervasive computing with wired and wireless networks of computing devices from desktops, notebooks to handheld computers. The trend is toward smaller, cheaper, more powerful and easier-to-use multimedia and Internet-ready computers. Better and faster communications through satellites give more extensive coverage. Distance education and virtual institutions bring quality and lower-cost education in the office, at school and at home, thereby relieving the pressure on traditional educational institutions. And, IT industries and cyber cities are being established in different regions of the world.

This era is characterized by unprecedented turbulence. When we are in the midst of a revolution, it is difficult but necessary to keep track of what is important and relevant, to make sense of our work and life, to “plan” the ephemeral, and to call for research and evaluation.

To capture the essential elements of the big picture, a framework for the analysis and synthesis of ICT education is developed in the rest of the chapter. This can be used as a lens to examine any country’s readiness and needs and draw up a strategic plan for ICT education, and continually update and adapt it to reflect the specificities and changes in space and time.

First, I perform a classical SWOT analysis in a comparative fashion to see how the three countries have defined their vision, mission, goals and strategies.
SWOT Analysis

The SWOT analysis (Mintzberg and Quinn, 1991) is performed by identifying the strengths and weaknesses within the country or system, and the opportunities and threats from outside. The following tables 5.1, 5.2, 5.3, 5.4, 5.5 summarize the exercise.

Building on the strengths, fortifying the weaknesses, seizing the opportunities and minimizing the threats, the countries have prepared their strategic plans for ICT education. The plans reveal their vision, mission, goals and strategies.

Analysis and Synthesis

The SWOT analysis, see tables 5.1, 5.2, 5.3, 5.4, 5.5 and empirical evidence from the three countries and regional ICT activities suggest that a possible framework to analyze and synthesize the state of IT education is in terms of some common themes:

Strategic Compact, Politics, Economy, Society and Culture

Country Comparison. All three countries have partnerships of the public sector with the private sector and civil societies. Since IT is an industry of the present and future, it seems to be a good business, which brings investment from the private sector.

When a charismatic leader, like President Lee Kuan Yew, Premier Tony Blair or Vice President Gore, explained the brighter future from IT, it rallied popular support, businesses to invest, and educators to accept it. The leadership drives the project or program. Processes are streamlined and new laws are enacted. Telecommunications company is semi-liberalized in Singapore and liberalized in UK and in U.S. Strategic alliances are concluded with suppliers and producers of IT.
### Table 5.1

SWOT Analysis: Strengths

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Singapore</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Literacy Rate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;14 years old</td>
<td>Tot</td>
<td>Male Female</td>
<td>Aged 9, 13</td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>95 83%</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Highest comp. Literacy</td>
<td>500 522</td>
<td>9, 13</td>
</tr>
<tr>
<td></td>
<td>in Asia ('90)</td>
<td></td>
<td>547 535</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>490 525</td>
</tr>
<tr>
<td></td>
<td>(over 800)</td>
<td>Aged</td>
<td>5.7 (exclude pre-primary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9, 13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td>515 511</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sci</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economy</td>
<td>$28,184 (1995)</td>
<td>4.1</td>
</tr>
<tr>
<td>GDP</td>
<td></td>
<td>9.9% (1998)</td>
<td></td>
</tr>
<tr>
<td>GDP Growth</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education Expenditure as of GDP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>as max. 6.8% in Norway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT spending as % of GDP</td>
<td>2.2</td>
<td>N/A</td>
<td>2.8</td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>636 35.5</td>
</tr>
<tr>
<td>Highspeed/broadband communications</td>
<td></td>
<td></td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>Wide coverage</td>
<td>Connecting home</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>Connecting home</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shops, offices, schools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT tech Index</td>
<td>Prim, L.Sec,U.Sec, Tot</td>
<td>Prim Sec Tot</td>
<td>Prim Sec Tot</td>
</tr>
<tr>
<td>Pupil:computer ratio</td>
<td></td>
<td></td>
<td>9:1 in '96</td>
</tr>
<tr>
<td>Internet connections at school</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multilingual</td>
<td>Yes. (multifonts)</td>
<td>No.</td>
<td>No.</td>
</tr>
<tr>
<td><strong>IT Industry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT</td>
<td>Very good</td>
<td></td>
<td>Very good</td>
</tr>
<tr>
<td>Manpower</td>
<td>Import</td>
<td></td>
<td>Import</td>
</tr>
<tr>
<td>Job Market</td>
<td>Very good</td>
<td></td>
<td>Very Good</td>
</tr>
<tr>
<td>Free Market</td>
<td></td>
<td></td>
<td>Free Market</td>
</tr>
<tr>
<td>Liberalized telecom</td>
<td></td>
<td></td>
<td>Liberalized telecom</td>
</tr>
<tr>
<td>Partnership public</td>
<td></td>
<td></td>
<td>Partnership public</td>
</tr>
<tr>
<td>Teacher Ed. and Training</td>
<td>Teachers trained first.</td>
<td>In-service Teachers trained first.</td>
<td>Teachers trained first.</td>
</tr>
<tr>
<td>Prim Sec.</td>
<td></td>
<td></td>
<td>Prin Sec.</td>
</tr>
</tbody>
</table>

Continued, next page.
Table 5.1, cont’d.:

<table>
<thead>
<tr>
<th>Freebee</th>
<th>Subsidized email accounts and computers.</th>
<th>Free email accounts. No freebee computers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free mail accounts and computers. (1 Notebook: 2 teachers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td>Technician Senior teacher of IT Univ.</td>
<td>Technician Senior teacher of IT Univ. 2nd level hotline</td>
</tr>
<tr>
<td>Teachers are trained.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Univ.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Comfort zone</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Students</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td>Ltd. Students’ emails</td>
<td>Ltd. Students’ emails Public and private production of local contents + applications</td>
</tr>
<tr>
<td>All students’ emails. Computer clubs</td>
<td>Production of local contents + applications</td>
<td>Production of local contents + applications</td>
</tr>
<tr>
<td>Production of local contents + applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information/Knowledge</strong></td>
<td>Virtually to all. Schools + libraries High</td>
<td>Virtually to all. Schools + libraries</td>
</tr>
</tbody>
</table>

In Singapore, the Advisory Committee on IT in Education advises the Ministry of Education. In England, BECTA (British Educational Communications and Technology Agency) and other collaborating partners advise the government. In the United States, the U.S. Department of Education contracts out studies for recommendations to the government.

Providing continuous funding for ICT education is a major sustainable factor.

During 1997 - 2002, Singapore devoted S$2 billion for ICT education program and S$600 million for teacher training for its relatively low population. For the same purpose, England allocated 105 and 205 million pounds sterling in 1999 and 2002, respectively. In 2000, United States provided $2 billion to support school IT program; $410 million for the Innovative Challenge Grant program and more money for other incentive programs.
Table 5.2
SWOT Analysis: Weaknesses

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>Singapore</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecommunications Liberalization</td>
<td>Partial liberalized, not competitive, high cost</td>
<td>Liberalized. Subsidized rate for schools</td>
<td>Liberalized. Subsidized E-rate</td>
</tr>
<tr>
<td>Standards Cellphone</td>
<td>GSM High</td>
<td>GSM High</td>
<td>Few standards Low</td>
</tr>
<tr>
<td>High Labor cost</td>
<td>High</td>
<td>Higher</td>
<td>Highest</td>
</tr>
<tr>
<td></td>
<td>But offset by available trained labor</td>
<td>But offset by available trained labor</td>
<td>But offset by available trained labor</td>
</tr>
<tr>
<td>Market</td>
<td>Small local market/ export oriented. Vulnerable to world economy</td>
<td>Large market (domestic, EU, commonwealth) Dependent on world economy</td>
<td>Large market (domestic, international) Dependent on world economy</td>
</tr>
<tr>
<td>Intellectual copyrights</td>
<td>65% (1995) (Mixed results)</td>
<td>N/A Enforced</td>
<td>35% piracy enforced</td>
</tr>
<tr>
<td>Cost/student</td>
<td>Prim Sec Total $4400  6300</td>
<td>Prim Sec Total(lbs.) 11  38  73</td>
<td>Prim Sec Total(2000) $276.18</td>
</tr>
<tr>
<td>Cost Adm IT Per user/yr.</td>
<td></td>
<td>4 8 18</td>
<td></td>
</tr>
<tr>
<td>Cost of email/teacher</td>
<td>1.7 8.8 2</td>
<td>0.2 2.7 &lt;1</td>
<td></td>
</tr>
<tr>
<td>Email/student</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abstraction. The new economy is characterized by globalization, liberalization, and greater reliance on knowledge for value creation. It offers new opportunities and challenges. Countries which can afford information and communication technologies (ICT) can use ICT as an enabler of broader national development goals or as a strategic focus of ICT industry or both. Education is one of the key areas of ICT as an enabler. Obviously, there are more benefits when the enabler brings a strategic industry focus. However, not all countries can develop sustainable ICT industries because they require investment in infrastructure, human capital, research and development.
<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Singapore</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry Expansion and job market:</strong></td>
<td>Attract ICT professionals</td>
<td>Plenty</td>
<td>Plenty</td>
</tr>
<tr>
<td></td>
<td><strong>Opportunities</strong></td>
<td>Demand &gt; supply</td>
<td>Import labor.</td>
</tr>
<tr>
<td></td>
<td><strong>Opportunities</strong></td>
<td>Import labor.</td>
<td>Retain leadership</td>
</tr>
<tr>
<td></td>
<td><strong>Opportunities</strong></td>
<td>More opportunities</td>
<td></td>
</tr>
<tr>
<td><strong>ICT Ed. valued</strong></td>
<td>Drives ICT education</td>
<td>Drives ICT education</td>
<td>Drives ICT education</td>
</tr>
<tr>
<td>Invest in ICT education.</td>
<td>(Re-)train teachers to deliver</td>
<td>(Re-)train teachers to deliver</td>
<td>(Re-)train teachers to deliver</td>
</tr>
<tr>
<td><strong>Improved pedagogy</strong></td>
<td>Student-centered: creative, collaborative</td>
<td>Student-centered: creative, collaborative</td>
<td>Student-centered: creative, collaborative</td>
</tr>
<tr>
<td>Reach out: connectedness</td>
<td>Connected to world.</td>
<td>Connected to world.</td>
<td>Connected to world.</td>
</tr>
<tr>
<td>Equity and access to education</td>
<td>Bridge digital divide successfully</td>
<td>Bridge digital divide fairly</td>
<td>Bridge digital divide fairly</td>
</tr>
<tr>
<td><strong>Competitiveness</strong></td>
<td>Research and development, leadership, competitive on market</td>
<td>Research and development, leadership, competitive on market.</td>
<td>Research and development, leadership, competitive on market.</td>
</tr>
<tr>
<td><strong>Collaboration/cooperation</strong></td>
<td>Strategic alliances</td>
<td>Strategic alliances</td>
<td>Strategic alliances</td>
</tr>
<tr>
<td></td>
<td>Distribution hub of Southeast Asia</td>
<td>EU, commonwealth market</td>
<td>International market</td>
</tr>
<tr>
<td>Quality of life</td>
<td>Improved</td>
<td>Improved</td>
<td>improved</td>
</tr>
</tbody>
</table>

Initially, computer education starts from an enterprising teacher who strongly believes that he or she can positively impact teaching and learning. Support for these initiatives propagate through volunteers, computer clubs, private schools, non-governmental organizations, local authorities and the state (Guruvadou, 1997).

Eventually, government intervenes with a national strategic plan in terms of initiatives, projects and programs.
Table 5.4

SWOT Analysis: Threats

<table>
<thead>
<tr>
<th>Threats</th>
<th>Singapore</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illicit material</td>
<td>Limited exposure to indecent material online.</td>
<td>Exposure to indecent material online.</td>
<td>More exposed to indecent material online.</td>
</tr>
<tr>
<td></td>
<td>Censure&gt;government controlled media.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virus attack</td>
<td>Risk to security unlikely from within (tough laws)</td>
<td>Risk to security</td>
<td>Risk to security. More exposed</td>
</tr>
<tr>
<td>Cultural push</td>
<td>Deculturalized. Offset by producing local contents. Regional pushers</td>
<td>Pushers through English language</td>
<td>Pushers through English language</td>
</tr>
<tr>
<td>Dependent economy</td>
<td>Small, export dependent country. More vulnerable.</td>
<td>Large internal and international market but dependent on Euro and on world economy.</td>
<td>Large internal and international market but still dependent on world economy.</td>
</tr>
<tr>
<td>Governance</td>
<td>Increased participation through e-governance. Threat to rightist dictatorship.</td>
<td>Increased participation through e-governance. Accountability Democracy</td>
<td>Increased participation through e-governance. Accountability Democracy</td>
</tr>
<tr>
<td>Technology bias</td>
<td>Technology centered development</td>
<td>Technology centered development</td>
<td>Technology centered development</td>
</tr>
<tr>
<td>ICT gap</td>
<td>Need for cooperation and technology transfer through bilateral agreements or international organizations</td>
<td>Need for cooperation and technology transfer through bilateral agreements or international organizations</td>
<td>Need for cooperation and technology transfer through bilateral agreements or international organizations</td>
</tr>
</tbody>
</table>

The government at state or federal level decides on its ICT education policy of a country as a function of its politics, economy, society, culture and education that it can or is willing to support in consultation with the stakeholders.
Policy makers try to put the stakeholders on board and sell them the educational plan that planners have produced by interweaving on the interface between the stakeholders and the policy makers. Influential stakeholders, e.g., businesses, usually pull the plan in their favor because they create most of the jobs and accept to fund a major part of the educational system. Applying business principles, businesses look for performance, efficiency of the system and the effectiveness of teaching and learning. The tensions created by the stakeholders and the students on the school should at best yield an excellent educational system.

Computer education requires a huge investment in terms of funding for infrastructure, human capital and alignment. The return on investment is long term. This calls for a strategic compact that includes a clear vision, goals, leadership, strategic alignment, coordinated action and new collaboration partnership. Good leadership is needed to get consensus from a large majority, to provide continued funding, to commit to make necessary changes in the laws and streamline practices, align strategically with local and foreign partners to sustain technology transfer, training and development. The state and the private sector should collaborate by government providing necessary incentives or contributions in high-risk new ventures and superstructures for entrepreneurship to develop content and applications, and infrastructure.

However, there are some major issues: the privatization and liberalization of telecommunication services to bring in competition for modernization and lower access rates; elimination of custom duties to promote the penetration of computers into schools, households, community and business; enforcing intellectual property rights; and overcoming the resistance to change.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>Singapore 1995-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vision/mission</td>
<td>To exploit the full potential of IT to ensure that we educate our children to be best with potential among the best in the world.</td>
<td>Engage pupils in ways that will help to realize their individual potential, whilst also offering teachers new opportunities to develop their professional skills in the classroom.</td>
<td>All children dream a 21st century educational access to 21st century technology.</td>
</tr>
<tr>
<td>Goals</td>
<td>Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase access to computers (pupils: Computer to be 2:1 by 2002) and to the Internet (all 4th graders and upwards will have email accounts by that date).</td>
<td>Include all learners through ICT’s ability to provide access to learning.</td>
<td>All students and teachers will have access to information technology in their classrooms, schools, communities, and homes.</td>
</tr>
<tr>
<td></td>
<td>Teaching and Learning</td>
<td>Improve teaching and learning.</td>
<td>Support innovation in schools, improving the effectiveness of schools and teachers, in particular, by using ICT to reduce the burdens placed on teachers and modernize delivery. Raise standards through the application of ICT across all areas of teaching and learning, particularly Key Stage 3.</td>
</tr>
<tr>
<td></td>
<td>Employability</td>
<td>Enhance linkages between schools and the world of work.</td>
<td>Equip school leavers with the ICT, information and learning skills needed for employability and lifelong learning and enable them to engage in a technological society.</td>
</tr>
<tr>
<td></td>
<td>Open World</td>
<td>Open up to the world through communications.</td>
<td>All students will have technology and information literacy skills.</td>
</tr>
<tr>
<td>Research and Development</td>
<td></td>
<td>Research and evaluation will improve the next generation of technology applications for teaching and learning.</td>
<td></td>
</tr>
<tr>
<td>Note</td>
<td>Connectivity, teacher education, learning, relevance of school to work, and opening to global awareness are the key ingredients.</td>
<td>The above goals drive a coherent program of funding and support addressing key areas of infrastructure, content, practice, and organization.</td>
<td>The above goals call for a leadership imperative to partner with various stakeholders.</td>
</tr>
</tbody>
</table>

*Form primary to secondary school – Stage 3.*
It is clear that progress in ICT education rests upon the pillars of the economy, society, culture, technology and education. On one hand, economically advanced countries (G8/OECD), mid-income countries, and newly industrialized countries (NICs) have societies and cultures that favor high investment in education and technology. On the other hand, many developing countries have problems of weak economy, poor infrastructure, high level of illiteracy and non-English language (even with different scripts) usage. For example, France’s ICT education program “Informatique Pour Tous” and Internet adoption were held back by weak support of Thompson proprietary hardware and French language-based “minitel” system, respectively. Also, Algeria gave up French to adopt English as the medium of teaching at school.

Concepts of equity and social justice vary internationally depending on the political regimes. In western societies, there is more concern for the above concepts. In computer education, access to computers with proper software at school, at home or in the community and to the Internet can bear on issues of the digital divide about class, gender and age.

**Digital Divide and Gender.** The rich children have home access to computers that are linked to the Internet and loaded with educational programs. Many are more knowledgeable and generally do better in ICT and across the curriculum than their less advantaged classmates. They can dominate others in using the computers or they can leave the computers at school to those who do not have computers at home. Class teachers are expected to find a delicate balance between the two extremes.

The digital divide affects the poor, the female gender and the older generation. The poor (generally from inner cities, rural, ethnic minorities and some senior citizens)
have insufficient access to computers and the Internet at home. The school provides some access to equipment yet quality software is lacking. The female gender lacks adequate supporting environment at school. There is a drop in the number of girls taking ICT in high schools and higher level.

Often, government policy is to bridge the gap by subsidizing computer systems, making available soft loans and tax-break donations from local businesses. The school dropouts and older community are also encouraged to go digital through community centers that are equipped by non-government agencies. In turn, these people can participate online in e-commerce, e-education and e-governance, and can help themselves with ICT or follow up their children’s schoolwork or participate in school activities.

Strategic Plan: Vision, Goals, Strategies, Action plan, and Funding

A plan is based on information from routinely collected data or survey data. Some useful metrics are computed. The past, present and future of the organization are examined, and the core business and the goals (where – the targets - we want to be from where we are now) are defined. This defines the vision and goals. By looking inward at the organization, strengths and weakness can be examined, and by scanning the environment, opportunities and threats can be assessed. How we achieve the goals are the strategies. A strategic plan is prepared involving all stakeholders through top-down and bottom-up negotiations so that there is consensus about and ownership of the plan. Implementation and evaluation are described in a Plan of Action. Leadership imperative
is the driving force of the strategic compact that ensures consensus, continuous funding, scalability, sustainability, and overall success.

Many of the above documents from different countries have been studied in order to understand the philosophy, the goals and strategies spelled out to realize success. In particular, I analyzed in terms of a SWOT analysis and their vision, goals and strategies from the strategic ICT education plans of the three countries under study. The three countries' goals focused on access, teacher training and learning, school and work, administration and management, and communications (see table 5.5). Visions, Goals and Strategies). Private sector participates alongside public sector in all three countries.

Singapore has four goals based on linkage between school and the world around, innovative processes, creative applications for lifelong learning and society, and administration and management excellence in education systems. The key dimensions are current assessment, learning resources, teacher development and the physical and technical infrastructure. To attract investors, the country enacted the Copyright Law of 1987 to protect intellectual rights, as they were not well observed in the region (local piracy was 63% compared to Malaysia's 98%, China's 94%; U.S. 35%, 1995).

England has four goals (new ICT plan 2001 – 2003): to raise standards through the application of ICT in teaching and learning, especially in literacy, numeracy, and stage 3 (middle school), to support innovations in schools, to equip school leavers with ICT skills for employability, lifelong learning in a technological society, and to provide universal access to all learners. These goals are being realized through strategies that drive a coherent program of funding (205 million pound sterling in 2000 from 105
million pounds in 1999) and support through BECTA in key areas of infrastructure, content and practice (becta.org.uk, May 20, 2001).

The U.S. has four goals: to provide universal access to ICT in classrooms, schools, communities, and homes; to empower all teachers to use technology to help students’ performance; to provide all students with technology and information literacy skills, to engage in research and devaluation for new technology applications in teaching and learning, and to use digital content and networked applications to transform teaching and learning. To realize the above goals, continuous sustainable funding is important. Two main federal government sources are: Technology Challenge Fund - $2 billion to support ICT development in schools and teacher training, and the Innovative Challenge Grant Program - $410 million, with an equal matching grant from the State in Project MEET for support to peers in a team-based school technology.

Data and Metrics

Planning depends on the availability of relevant, up-to-date, complete and quality data. It is difficult or impossible to find all the data needed to evaluate the needs of countries adopting ICT education. Often, without proper planning, ICT is introduced for its mass appeal and political gains. Sometimes the secondary statistics for the three country case studies refer to different years and are not directly comparable but are indicative. First, the context of the data is discussed and then the list is drawn out as a set of metrics that determine the readiness and maturity of a country to adopt an ICT education.
Some indicators are useful to assess certain parameters in educational planning, describe some trends in policy, determine the effects of policy changes and compare educational systems in terms of similarities and differences. The basic components of education are enrollment, expenditures, outcomes; the initial situation is the demographics and the characteristic situation is the economy. These components provide substantive indicators and the context within which the indicators are to be examined. The context provides an understanding of the educational systems and the social structures of different countries (nces.ed.gov, March 19, 2002).

The contextual factors and indicators that are useful to consider for ICT education are shown in this section below. To avoid duplication, see the comparative indicators in the SWOT analysis section.

A country’s population and land area influence both the organizational structure and the infrastructure of its educational system. Countries that have a large number of school-age children face greater demand for educational services. Those with large areas face greater challenges in providing educational services since the resources must be spread over a wider geographical area. High population densities may make it more efficient to support a wider range of specialized education and training opportunities. Although these factors influence the degree of centralization and the extent of provision of services, they become critical when the density is either too large or too small. Otherwise, factors such as culture, history, economics, and politics have a stronger influence on the structure of an educational system (nces.ed.gov, March 19, 2002). However, the deployment of ICT education is attractive since the additional cost of increase coverage is relatively small compared to the initial cost of putting the
infrastructure in place. For example, having placed the satellites in place, Canada, India and China can afford penetrating with ICT education into remote villages; United Kingdom, Germany and Malaysia can dispense ICT education nationwide over the networks: National Learning Grid, Schulen and Netz, and Multimedia Super Corridor, respectively.

The economic power rests on the productivity of the people and the Gross National Product (GDP) per capita measures it. It reflects the capacity of a country to invest in socio-economic services, including ICT education. Free market and to some extent mixed market systems allow for enterprise, strategic alliances and competition (in many countries the telecommunications industry is government-owned and non-competitive; it handicaps the IT industry).

Normally, a country is ready to embrace ICT education when the telephone (wired and wireless in the near future) density is high, which allows for Internet access. Internet penetration depends on the certain factors, see Infrastructure section below. Information about computer use in schools is valuable as countries contemplate the role of computers in education. The percentage of schools using computers for instructional purposes reflects, in part, national policies on the introduction of computers into education, whereas the student/computer ratio provides a measure of student access to computers. At present, the connection to the Internet is important.

Digital divide is the socio-economic, racial/ethnic, gender and age gaps in access to computers and the Internet. Students in schools in poor and rural areas have less access to computers, quality software and the Internet. The household IT density, i.e., the number of computers with Internet connection per 1000 households, and the
community (centers) IT density, the Internet access rate (E-rate in US is preferential tariff for schools and communities), girls’ enrollment rate in ICT classes are important measures that help expose the severity of the digital divide.

The other variables that influence the quality of ICT education are the quality of hardware, software, curriculum relevance, usage time and instruction, coverage in terms of teaching across the curriculum, number of ICT-trained general teachers and ICT specialist teachers, the ICT literacy rate of heads/rectors and inspectors, and other school ICT activities.

The contextual factors and metrics that could be considered for ICT education are shown below in table 5.6.

The metrics for the three countries are not computed here to avoid some duplication from the SWOT analysis tables. However, a revised version of the metrics for the case study of Mauritius is produced in full in Chapter 6.

Information Infrastructure

Country Comparison. Table 5.7 summarizes the information infrastructure for the three countries (shown in bold) and for other countries. Evidently, a high telephone penetration or other telecommunications facilities favor the infrastructure for ICT education.

The United States is more advanced in technology. The Index of Technological Progress shows the relative position of the three countries as being: Singapore 52.95, United Kingdom 52.20, and U.S. 100 (see Appendix B) (Rodriguez, 2000).
<table>
<thead>
<tr>
<th><strong>Contextual Factors</strong></th>
<th><strong>Metrics</strong></th>
<th><strong>Purpose</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics and land area</td>
<td>Population density per square mile</td>
<td>Organizational structure and infrastructure of the educational system</td>
</tr>
<tr>
<td>Economy</td>
<td>Gross Domestic Product (GDP) per capita</td>
<td>Capacity in terms of productive or economic power to provide, amongst other things, educational services for the people.</td>
</tr>
<tr>
<td>Culture</td>
<td>Technological</td>
<td>Educated, trainable, adaptable to change.</td>
</tr>
<tr>
<td>Society</td>
<td>Educational level</td>
<td>Literacy, adoption and adaptation capacity.</td>
</tr>
<tr>
<td>Education</td>
<td>Educational level</td>
<td>ICT usage. Trainable. ICT Productive</td>
</tr>
<tr>
<td>ICT Readiness</td>
<td>Telephone density/DSL access points. Internet access rate. No. of ISPs. Type of service</td>
<td>Readiness for network/Internet connection. Telecommunications cost. Competition and quality. Internet usage; support for multimedia.</td>
</tr>
<tr>
<td>Digital divide</td>
<td>Household ICT density and Internet access rate. Hours. Bridging class divide. Community ICT density with Internet access. % of senior citizens with access to computers or Internet (at home). % of girls taking related ICT courses at schools.</td>
<td>Connecting the community, parents, and children to school during after school. Number of community centers with computers and appropriate software. Age divide Gender divide</td>
</tr>
<tr>
<td>ITC Park</td>
<td>% of schools using computers. No. of computers per classroom. Student:computer ratio. % of classrooms w/Internet connections. % of machines connected to Internet</td>
<td>Computer penetration rate. Compuer penetration rate. Disparity from 1:1 (ideal) Level of educational experience. Internet access rate. Internet access rate.</td>
</tr>
</tbody>
</table>

Continued, next page.
Table 5.6, cont’d.:

<table>
<thead>
<tr>
<th>Contextual Factors</th>
<th>Metrics</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT professionals</td>
<td>No. of ICT professionals per 10,000 people.</td>
<td>ICT skills to support operation and maintenance of ICT. Software development.</td>
</tr>
<tr>
<td>ICT Usage</td>
<td>Curriculum relevance.</td>
<td>ICT skills (or technology and information literacy skills – TILS)</td>
</tr>
<tr>
<td>Quality of hardware</td>
<td>At least Pentium PC multimedia, possible Internet connection or equivalent (Mac).</td>
<td>Level and quality of ICT education.</td>
</tr>
<tr>
<td>Quality of software</td>
<td>MS Office. Educational software for various subjects, micro-worlds simulations</td>
<td>Quality and level of use. Enriching experience. Performance.</td>
</tr>
<tr>
<td>Time usage</td>
<td>Hands-on hours.</td>
<td>Practice, usefulness</td>
</tr>
<tr>
<td>Instructional usage</td>
<td>Instruction hours</td>
<td>Pedagogy</td>
</tr>
<tr>
<td>Coverage</td>
<td>Number of subjects involving using ICT</td>
<td>ICT usage across curriculum</td>
</tr>
<tr>
<td>Teacher availability</td>
<td>Students-teacher ratio</td>
<td>Teacher’s load in terms of no. of students</td>
</tr>
<tr>
<td>Teacher workload</td>
<td>No. of contact hours</td>
<td>Teachers’ work-load in terms of time.</td>
</tr>
<tr>
<td>Trained teachers</td>
<td>% of ICT-trained general teachers</td>
<td>Quality of teaching. Teaching about ICT across curriculum</td>
</tr>
<tr>
<td></td>
<td>% of specialist teachers</td>
<td>ICT-subject teachers and support</td>
</tr>
<tr>
<td>Heads/Directors</td>
<td>% of ICT literate Headmasters/Rectors/Inspectors</td>
<td>ICT literate change agents</td>
</tr>
<tr>
<td>Parents</td>
<td>% of parents conversant with ICT</td>
<td>Parents help to children and involvement with ICT education</td>
</tr>
<tr>
<td>Activities</td>
<td>Non-curriculum tasks. Publications.</td>
<td>ICT support/usage for administration, class management, reporting, publishing, library</td>
</tr>
<tr>
<td>Research &amp; evaluation</td>
<td>No. of quality (publishable) research papers. Reports</td>
<td>Improvement/sustainability. Assessment</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Workshops, seminars, conferences</td>
<td>Platform for consensus building</td>
</tr>
</tbody>
</table>
Table 5.7

Countries, including Singapore, U.K., and U.S.A., with Population, Phone Penetration Rate, GDP and IT Spending. Groups of European Countries, Some Advanced NICs, Some G8 Countries, Some New NICs/Advanced Developing Countries

| Country   | Size* (’000) | Population* (millions) people | Cell Phones per 1000 people | Connections to Internet | New IT Index* | GDP/ capita ($) | GDP Growth rate | IT spending as % of GDP | Computer household ratio+
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>5.1</td>
<td>577</td>
<td>21.3</td>
<td>63.3</td>
<td>9.3</td>
<td>17,210</td>
<td>4.4</td>
<td>2.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Finland</td>
<td>5.0</td>
<td>542</td>
<td>292.4</td>
<td>23.9</td>
<td>8.0</td>
<td>28,184</td>
<td>9.9</td>
<td>2.2</td>
<td>1:3</td>
</tr>
<tr>
<td>N. Zealand</td>
<td>3.4</td>
<td>439</td>
<td>131.3</td>
<td>41.1</td>
<td>8.3</td>
<td>21,736</td>
<td>3.0</td>
<td>1.6</td>
<td>1:3</td>
</tr>
<tr>
<td>Norway</td>
<td>4.3</td>
<td>515</td>
<td>296.1</td>
<td>29.4</td>
<td>7.4</td>
<td>13,372</td>
<td>6.0</td>
<td>1:20</td>
<td>1:20</td>
</tr>
<tr>
<td>Sweden</td>
<td>8.6</td>
<td>690</td>
<td>281.8</td>
<td>11.3</td>
<td>7.2</td>
<td>16,197</td>
<td>4.1</td>
<td>2.8</td>
<td>1:3</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>6.2</td>
<td>448</td>
<td>211.0</td>
<td>13.5</td>
<td>9.0</td>
<td>31,567</td>
<td>4.1</td>
<td>2.8</td>
<td>1:3</td>
</tr>
<tr>
<td>Singapore</td>
<td>2.2</td>
<td>365</td>
<td>147.5</td>
<td>7.8</td>
<td>7.8</td>
<td>38,124</td>
<td>9.9</td>
<td>4.4</td>
<td>1:3</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>9,629.0</td>
<td>252.6</td>
<td>161.9</td>
<td>35.3</td>
<td>7.8</td>
<td>35,567</td>
<td>4.1</td>
<td>2.8</td>
<td>1:3</td>
</tr>
<tr>
<td>Japan</td>
<td>124.0</td>
<td>552</td>
<td>461</td>
<td>36.9</td>
<td>3.0</td>
<td>21,736</td>
<td>3.0</td>
<td>1.6</td>
<td>1:3</td>
</tr>
<tr>
<td>U.K.</td>
<td>244.8</td>
<td>59.6</td>
<td>521</td>
<td>1.7</td>
<td>6.3</td>
<td>21,736</td>
<td>3.0</td>
<td>1.6</td>
<td>1:3</td>
</tr>
<tr>
<td>Taiwan</td>
<td>36.0</td>
<td>22.3</td>
<td>467</td>
<td>1.7</td>
<td>6.3</td>
<td>13,372</td>
<td>6.0</td>
<td>1:20</td>
<td>1:20</td>
</tr>
<tr>
<td>Korea</td>
<td>435</td>
<td>73.0</td>
<td>88.5</td>
<td>1.7</td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>88.5</td>
<td>1.7</td>
<td>2.8</td>
<td>6.6</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Africa</td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mauritius</td>
<td></td>
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<tr>
<td>China</td>
<td></td>
<td>997.5</td>
<td>450</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.5</td>
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<td></td>
</tr>
</tbody>
</table>


* Index of Economic Freedom, 1999, Heritage Foundation;

* Index of Technological Progress, 2001


Blank means not available

Abstraction. The Internet spans world connectivity for transmitting data and services. Information superhighways or "Infobahns" have broad bandwidth to support large volume of communications, faster access and high quality contents. They connect via gateways to the Global Information Infrastructure (GII). No wonder, the craze is that everyone wants to get connected to the Internet.
In 1998, a framework was presented in *The Global Diffusion of the Internet Project: An Initial Inductive Study*, which described Internet penetration by six dimensions, namely, pervasiveness, geographic dispersion, sectoral absorption, connectivity infrastructure, and sophistication of use, has been applied to more than 40 countries. A nation’s readiness to embrace modern IT technology can be measured by the telephone (cable or wireless) penetration rate where a high telephone penetration rate favors Internet connectivity. The IT diffusion rate is often described in terms of four metrics: (a) the telephone density or penetration rate (number of phone lines per 1000 people), or number of customers or direct satellite link (DSL) access points or the number of computers connected to the Internet (Internet penetration), (b) the number of computers in the park for standalone computers and, for educational use, the ratio of pupils to computers (number of pupils to a computer), (c) the number of computers in the households, and (d) availability of broadband service for quality and range of services offered. Just as a nation’s commitment to ICT is reflected by the amount spent on ICT as a percentage of the GDP, in the same way, its ICT education is reflected by the amount spent as a percentage of the national budget. Both measures are functions of the economy, technology, culture and education.

From Table 5.7, it is noted that both sparsely populated countries (US and Slovenia) and densely populated islands (Singapore, Taiwan and UK) with significant GDPs have invested in ICT because there is a greater need (see telephone penetration rate and IT expenditure as a percentage of the GDP) for communication within and overseas. UK and USA were the cradle of the Industrial and Information revolutions, and their societies and cultures have favored investment in technologies and technology
education. Taiwan and Singapore are NICs that have raced through the phase of industrial development to the forefront of the information society by adopting different models of development from the West by the right amount of government interference into education, training, investment, employment, etc., to correct for the imbalances of free market forces. With a high growth rate (despite the collapse of the Asian banking system), they can afford to invest into ICT for the coming of the knowledge society where the competition is for wealth creation.

The exception to the countries that are mentioned in the preceding paragraph is India, a developing country, with a high population density and a GDP per capita of only $450 but a GDP growth rate of 6.5 %, is a world major software producer. By using satellite technology and distance education, the country is investing into education even in remote villages. ICT education is mostly dispensed in the major cities. Thus, IT gives hope to poor countries that, in investing into human capital and “modestly” in ICT, they can leapfrog to wealth creation.

All these societies favor an ICT education, which usually starts at the University level and permeates downward through secondary, primary and even pre-primary levels. Singapore prioritized ICT from junior high-to-high school and then to primary school. Slovenia emphasized the diffusion of ICT in primary schools. Taiwan is catching up with ICT education in the primary and teacher training schools. UK has a mandated ICT program and national curricula for all levels and they are integrated over the National Grid for Learning network. In US, there were more experimentation and exploration at different levels of schools, districts, counties and states until the national
strategic plans of 1996 and 2001, which have brought leadership imperatives to provide infrastructure, standards, structure, funding and support.

**Infrastructure (Hardware, Network, Computers, Software and Internet)**

**Country Comparison.** In all three countries, one of the main goals is building the ICT infrastructure in schools, i.e., increasing the number computers with multimedia and Internet connections, and networking the computers into Intranet in the schools.

From the SWOT analysis Table 5.2, the number of computers in schools, the percentage of schools with Internet connections, and the pupils: computer ratios are compared. Evidently, Singapore has the advantage of being small and has a high GDP per capita. It achieves a ratio of two computers to one student.

**Abstraction.** Computing technology evolves at a tremendous rate. According to Moore’s Law, computing power doubles and cost halves every eighteen months (Capron, 1998). Miniaturization leads to reduced size, forms and costs, and hence to portability and affordability: desktops, laptops, notebooks, palmtops, and cellular phones that are wired or wireless connect to the Internet. Some appliances with embedded systems are connected using Bluetooth technology. Pervasive computing devices provide mobility and connectivity. According to International Data Corporation, there will be 48 million non-PC devices accessing the Internet by 2001 and it predicts that about half of the web-enabled devices sold by 2002 will be non-PCs (Hansmann, Merk, Nicklous, & Stober, 2001).

There are new technologies around and some will be popular in the school environment. Already, notebooks are becoming increasingly popular in higher
education. Soon, the mobile phone, which can access the Internet, will find its way into education. “Mobile phones are rapidly becoming the preferred means of personal communication, creating the world’s largest consumer electronics industry. In 1997, there were more than 100 million mobile phones were sold worldwide” (Interactions, 1999, p. 24). “There will be as many as 1.6 billion cell phone users worldwide by 2005 (Newsweek, 2000, p. 63). The need for keyboarding will be superseded by handwriting pad and voice technology. Children will speak into these wireless machines that will respond with powerful multimedia of sound, video and data. Computers will really be powerful extension of the mind (Papert, 1980).

In sum, the computing paradigm is connectivity and integration. It ensures open, portable, integrated and connected systems with software architecture. The client-server model for accessing information is client-thin server-thick. Individual access for a group of learners is made possible via asynchronous delivery (Stern, Steinberg, Lee, Padhye, & Kurose, 1997) and for a group via synchronous delivery to individual computers or videoconference. Multimedia, which consumes bandwidth and memory, is driving the computer market as it impacts learners strongly. Wireless connectivity provides access anywhere and anytime – pervasive computing.

Standalone desktop personal computers (PCs) are increasing being connected into a local area network (LAN), which can in turn be connected to bigger networks like wide area networks (WANs) or metropolitan area networks (MANs), and the Internet through bridges, routers and gateways. Being connected to the Internet means that the classroom or school is connected with external resources, like schools, electronic libraries, communities, stakeholders, states, countries and people, to communicate,
share resources and to learn about the world. Parents, teachers and the community will be connected to the school; they can learn and share the school resources as well as participate in the learning experience of children.

Sometimes commercial interests have produced dubious pedagogical quality of software. Many multimedia software for home users are in fact “edutainment” rather than truly educational. Improvement in the quality of educational software is highly desirable. Neither programmers nor teachers can develop the software separately. They need to team up for the programming, instructional design, contents and evaluation. By using the software learning should take place; Good software optimizes the process. Computer-based learning (CBL) is meant to facilitate the learning experience whereas computer-aided instruction (CAI) are drill exercises that are meant to reinforce learning through practice. Intelligence tutorial systems uses artificial intelligence to profile the user’s level and needs to map the certain material to learn to the ability level of the user. Most of the modern multimedia software has an authoring component, which allows teachers to customize the software for his or her class. Micro worlds and simulation packages provide “experience rich” learning environments.

While business is needed to support and partner with the development of ICT education, it is important to be careful that their self-interest does not take precedence over the true pedagogical function.

Distance Education and Virtual Institutions

Country Comparison. Singapore is well connected electronically to and has strong partnerships in education with the major centers of learning in the world. Besides
it is exporting its expertise to the South-East Asia region, which benefits widely in distance education. In England, the Open University in England offers a variety of courses and in particular, since 1994, a distance education course for pre-service teachers. In the United States, distance education is fashionable as educational institutions get online and want to cut down on costs. The University of Phoenix is one of the largest virtual universities where all courses are online and it is available all over the world.

In Asia, there are over 100,000 students following distance education. Similarly, in India, the Indira Gandhi Open University offers online courses at incredibly cheap prices. So ICT brings to the remote developing areas of the world the best educational courses at competitive prices.

Distance Education. Likewise, many courses are offered in distance education mode that allows non-traditional students and life-long learners to continue their studies while being engaged in some occupation during the day. A blend of distance education and face-to-face class meeting are generally available. Virtual talks, discussions, seminars and conferences are available through video and/or audio conference. Web-based courses take students through their own pace, wherever they are and whenever they find time. Schedules and reading materials, supplementary exercises are posted ahead of time. E-training or “e-ducation” can cost less as overheads are reduced. In the cyber world, distance is no longer important except maybe the communication rates for surfing the Internet but email and chat are free. Students engage in electronic conversations (chats) or in group discussions (collaborative and cooperative learning, e.g., using e-Groups from Yahoo), receive personal help from teachers, submit
assignments that are time-stamped and receive back their graded work with feedback. Turnaround time is fast and students can learn from their mistakes and improve in a shorter time thereby decreasing their learning curve. Curriculum materials are adapted for different ability levels and learning styles. They can check their individual progress book and overall class performance. Such systems are also offered by corporation for training and also exist in some primary and secondary schools. Thus home, office and elsewhere are becoming extensions of the school. Parents and the community can participate in the education system. True to his or her nature, the digital child will learn and play in flexible schedules that maybe termed school without wall.

**Virtual Institutions.** And almost all major universities are offering some form of distance education online. As competition builds up, the need to offer quality courses at competitive prices is pushing some virtual institutions into strategic alliances with the best institutions in respective fields, irrespective of location or national boundaries. Accreditation, and examinations, and maybe curriculum development, are contracted out. The business of teaching becomes the strengths of these supra institutions of e-learning. For example, in Mauritius, private tuition is also being offered on-line thus eroding the cancer of education that exists alongside the official school system.

**Educational Institutions, Restructure, Curriculum and Renewal**

*Country Comparison.* While respecting confidentiality, all three countries' education systems have become transparent to the public through school and Ministry of Education websites. Curriculum renewal has incorporated digital content, technology and information literacy for employability, lifelong learning and active participation in
the technological society. The emphasis is on the process of learning and applying ICT in creative and innovative ways. Singapore is small; it has a recent educational architecture, with a new technological infrastructure and centralized planning. The national curriculum sets the guidelines for ICT programs in schools. It has been successful at the restructure. The British education system is decentralized but traditionally good. The planning and organization is excellent. Its early start with the Micro-electronics Project had given it an edge. In UK, The Education Reform Act 1989 enacted a staged implementation of the National Curriculum that has enforced attainment targets in core and foundation subjects, levels of attainment and compulsory tests at four key stages. The curriculum is the most advanced of all with the National Grid for Learning becoming the unifying medium linking all educational resources. The United States has a decentralized system of education with more variability. There is more experimentation in charter schools. There are islands of excellence, like in England. There is no state or national ICT framework as for other subjects yet.

**Abstraction.** There is general agreement that the school must adapt itself to the changing real world. This renewal process always affects the curriculum but this time ICT is challenging the very walls of the school by extending the school into the home, involving business in the affairs of the school and becoming transparent to the community.

School is expected to be a nurturing environment where pupils spend a significant part of their lives learning, hoping to be equipped with a foundation education to live successfully and independently. To many, it is a disappointment. It may be too late to do anything by the time a disadvantaged student leaves school. For
the common people, one’s future is more or less destined by the school results. What are the educational parameters that determine equity, social justice, fair access, performance, effective teaching and learning, efficiency, funding, and stakeholders’ role?

In theory, the public school, which is the funded from taxpayer’ money, should provide access to school and its resources to all students and teachers, and be fair irrespective of creed, color, gender and economic status. So for ICT education, all pupils should have equal access to computers at school and to quality educational software, which is disparagingly different from affluent to poor communities. In countries where the state funds education, the digital gap is practically resolved uniformly but the scarce resources are spread thinly across the state. However, the some disparity may still exist between urban and rural development due to inadequate or primitive infrastructure in rural areas.

But it is known that funding is scarce; school is not all that interesting after all and many students are dropping out; literacy and numeracy are low; teachers’ moral is low; performance in inner cities and minority schools are abysmally low. Students prefer MTV and arcade games to reading books or doing homework. Wastage is high.

With the advent of educational technology, especially multimedia, educators want to capture the imagination of children and make learning fun and effective by implementing different learning styles. They write multimedia e-book with streaming videos and Disney-like graphics. So schools invest in computers and link them to the Internet. This new technology has many adepts but is enormously costly.
Do children learn better and do the benefits of ICT education outweigh the cost compared to the traditional system? More research is needed because to-date there are mixed results (futureofchildren.org, March 30, 2000). Yet everyone wants to jump on the bandwagon of ICT education. Even Japan, which earlier deployed conservatively ICT in schools, has reversed direction with massive input.

**Curriculum.** School administration can have closer or tighter control yet teachers can have flexibility in teaching. Completing the syllabus and achieving good results for competition often undermine good practice in more enriched learning.

A large number of countries aim at providing technology and information literacy skills (TILS) to students through universal access to computers and to the Internet in order to prepare them to participate fully in our technological society.

At present, most computer education programs at school focus on isolated technical skills that consist of a description of the parts of the computer, applications using word-processing, spreadsheet and database (possibly information search from a CD-ROM database), and Internet search (if all students can access Internet). A new level of literacy is needed that will promote strong basic academic skills; thinking, reasoning and teamwork; and proficiency in using technology. TILS require students to become more proficient information and technology users:

- to define a task, realize that an information need exists, define the problem, identify the types and information needed, develop information-seeking strategies (consider all information sources and develop a plan for searching),
- to locate information from a variety of sources and access specific information found within individual resources,
• to use information by engaging (reading, viewing and listening) the information
to determine its relevance and then extracting the relevant information,
• to synthesize information by organizing and communicating results of
information in the problem-solving effort, and
• to evaluate how well the product meet the original task (effectiveness) and the
process of how well the student carried out the problem-solving process
(efﬁciency)

Assessment. All three countries are carrying research into new forms of
assessment in terms of portfolios of students' achievement rather than in-class
examinations or a combination of both. Creative and innovative work can be achieved
through project work. But there is a trend in the United States to enforce more testing.
England has been traditional in the examination-based assessment although there are
new ways that are being explored.

Renewal. Single-user personal computers (PCs) have a practical life of five
years and PCs with multiple users in schools have a practical life of two to three years.
One sound policy of replacement, as applied elsewhere in streetlights, important parts in
vehicles, etc., is to replace the whole park by new ones. This maintains more uptime,
adopts newer technology at less than the previous initial price, and saves on
maintenance contracts. However, many schools could not afford to replace sets of
computers regularly. Many computers have been crippled because there is no
maintenance contract at all or simply there is no budget for supplies of paper, ink or ad
hoc repairs. Some schools raise funds from the community, others receive donations
from corporations, and still others have high school students recycled used computers
that were replaced from offices of businesses. Also, governments are more and more making a commitment to support ICT in schools.

Restructure/Change. Educational systems undergo periodic changes according to strategic plans of development in order to adapt them to the changing needs of society, which are often dictated by the economic, technological and political environment. Even UNESCO and the World Bank have shifted emphasis and themes. The point is that turbulence in the long term is unpredictable. At best, the short term gives some degree of ease. Changes and adaptation are part of life.

Just as businesses restructure, schools need to revise their curricula, investment and their structures, and teachers change their teaching styles and use educational technology to enhance teaching and learning. ICT provides an opportunity to restructure education. With distributed computing, management structure can be decentralized so that schools can be more accountable and yet can be tightly controlled and administered effectively from headquarters. When the classroom computers are linked to the Internet, the outside world comes virtually at teachers and pupils’ fingertips. Resource materials can be shared and pupils can work collaboratively in interesting projects across cultures. Different teaching styles and learning styles can be explored, e.g., exploratory and experiential learning in simulations and “information rich micro world” environments, reinforced learning in online revision, research over the Internet where judicious choice of materials that are relevant to the topic in hand can be selected, interpreted, and written in one’s own words (not cut and paste), etc. By continually monitoring changes in the school environment, incremental changes to the plan can be made.
Learning

Country Comparison. The arsenal of ICT at schools is to increase learning. There is need for a lot of research into methods that are effective in learning when ICT is used in the class. In all three countries, there is on-going research. These countries have invested a lot into ICT in education and ICT have become at the center of learning experience. The United States second strategic plan for technology in education (2001) stressed that technology should be at the center of education and not at the periphery. However, it is important to note that some countries in Europe insist that ICT should be at the periphery of learning (myweb.worldnet.net, October 23, 2001). The mediation model reduces the dependence on technological resources and places interpersonal relationships at the heart of the learning process. It is interesting to see the evolution and results of the diametrically opposite philosophies. I believe that many countries will adopt a position on the continuum based on affordability. It is noted that Japan initially resisted ICT diffusion in primary schools but recently conceded through a massive input of ICT.

Abstraction. The theoretical foundation of learning is dealt with in Chapter 2. According to Jean Piaget (1936, 1963), learning and thinking involve the participation of the learner. Multimedia technologies and the Internet enable improve the quality of learning by facilitating access through hands-on and interactive to resources and services, remote exchanges and collaboration.. Laboratories, workshops, Internet-linked networked classrooms, and technologies encourage interactivity, such as multimedia, hypermedia and virtual reality.
The use of ICT in education is motivated by the fact that the knowledge society requires new skills and ICT facilitate learning. The new basic skills are foreign languages, entrepreneurship, production of information and knowledge, science, culture and citizenship that will be acquired in a process of lifelong learning. Technological, intellectual and social skills are becoming essential for living, working and participating actively in a knowledge society.

Teacher and Administrative Staff Education and Training

This is a major priority for any country. We focus on the three cases to find out what were the strategies and how successful they have been.

Country Comparison. At a time of scarce human resource in IT, Singapore started directly with teacher training in a Project called the Students and Teachers’ Workbench, and provided free computer and email accounts. The teachers used self-learning materials and computer-aided-instructions (CAI), and developed curriculum materials, which were compiled and used subsequently with others. Now they form the Digital Media Repository, which is accessible on the network. Every two teachers are provided with one free notebook computer, free access to the Internet at work and at home, in order to foster familiarity with their professional tool. Consequently, they prepare lessons, explore creative ideas and innovative methods, and network with colleagues, students and others.

In England, the Computer Literacy program started with pre-serviced teachers. Soon, these teachers got discouraged with the added responsibility, excessive time and energy required, and with no compensation. Many dropped out of the program. So, pre-
service teachers were trained. They were easier to adapt to the new learner-centered pedagogy. The universities supported the young teachers in their efforts to integrate technology. Senior IT teachers gave them support to teach. Finally, equivalent full-time technicians support the maintenance and repairs of the computer systems at schools. By 2000, 89% of the teachers were trained, with a breakdown of 90% primary and 85% secondary school teachers. However, teachers who felt confident to integrate technology into the curriculum were only 63% total, and 65% primary and 61% secondary teachers. All teachers are encouraged to purchase a computer at a reduced rate thereby encouraging more teachers (from 58 to 89 percent) to use of ICT in their teaching. Sixty percent of teachers believe that owning their computer has increased pupils' attainment quite substantially (becta.org.uk, May 20, 2002). Now, let us consider the school administrative and management. Managing information electronically should be part of everyday business in areas like computerize administration system, assessment, recording and reporting and electronic registration. It should help raise standards and encourage e-governance for transparency.

Indicators are useful to assess certain parameters in educational planning, describe some trends in policy, determine the effects of policy changes and compare educational systems in terms of similarities and differences. The basic components of education are enrollment, expenditures, outcomes; the initial situation is the demographics and the characteristic situation is the economy. These components provide substantive indicators and the context within which the indicators are to be examined. The context provides an understanding of the educational systems and the social structures of different countries (nces.ed.gov, March 19, 2002).
The contextual factors and indicators that are useful to consider for ICT education are shown in Data and Metrics section 3 above. To avoid duplication, see the comparative indicators in the SWOT analysis section.

In the United States, teacher training in IT became a priority in public schools in the early nineties. There were about three million teachers. In 1993-93, only 14% of public school teachers had more than eight hours of training, given that 50% of teachers had little or no experience at all with technology. By 1999, one-third of teachers felt comfortable to use computers and Internet in classroom instruction, and 50% had more than eight hours of technology professional development. Teachers have been trained and have free email account at work, but no other freebee (I believe). The issues reported by public school teachers in two studies carried out in 2000 were: release time, practice and plan ways to use computers or the Internet (83% of public school teachers), support for integrating telecommunications into the curriculum (68%), training opportunities (66%), technical support or advice (64%), administrative support (43%) (nces.ed.gov, March 19, 2002). In one state out of 27 states, which participated in the second study, it took between fourteen hours to seven days to fix a reported problem in a school when the average response time was over two days. There is federal funding for teacher training and school-based technology teams to encourage peer support to integrate technology into the curriculum. Additionally, Massachusetts offers matching grant in Project MEET for teacher training.

In Denmark, a pedagogical ICT driver's license is required of teachers of ICT. In Sweden, since 1996 a law has required basic ICT skills from all new teachers;
those who have completed a special training program receive a multimedia PC for use at home.

**Abstraction.** There is a severe shortage of ICT teachers all over the world. Training is required for pre-service as well as in-service teachers. Some in-service teachers have been attracted to the new technology but after a few years the interest wanes, especially, when there are no incentives to reward them for the tremendous amount of preparation time. Computing, Mathematics and Science have largely benefited from in-service crash courses. However, teachers from other subjects face more difficulties to assimilate crash courses and longer-term courses are indicated. Both generalist and specialist teachers for ICT are needed. Generalists can teach across the curriculum and specialists can teach ICT as a subject and provide support as advisors.

There are two approaches to teacher training, namely, utilitarian and critical. The utilitarian approach is a shallow-technical vision of improvements, a quick fix using worksheets and similar means to gain skills. The critical approach attempts to change both teachers and learners’ knowledge structures and thus require a much broader curriculum approach. The latter approach is more successful but time consuming; it requires the teacher and the students to be more reflective; the teacher’s role is to facilitate learning and promote learner’s autonomy. Such change is difficult to make for a whole school because of the rigidity of the schedules and teachers or head-teachers/rectors’ resistance to change. It requires a new flexible approach to teaching and learning.

All countries have to adapt the training of teachers to their own flavor within their means. However, there are some notable things that some countries have done well
and there are also some mistakes that affected the adoption of ICT in schools. For example, England and Wales, and Mauritius, launched the application of ICT in education through in-service teachers and found out that the process slowed down as established teachers find it hard to modify their existing practices and school administration was rigid. New teachers are predisposed to major changes in teaching style that is required for the powerful use of IT to enhance teaching and learning.

The following are some of the strategies that have been used:

- Teachers and institutions need to own the process of change, staff development needs to be increasingly diversified across all subjects, and teachers themselves need to engage in the search for ways in which IT can enhance teaching and learning (Brown, 1993).

- Teachers and students need hands-on practice with the computer and good educational software. Often, they have to share the equipment because there are not enough computers. Unlike a television set that can be watched by many people, a computer is interactive and requires learning by doing.

- Teachers have part-funding, soft loans to purchase or rent equipment for the government projects to develop software, curriculum materials, regional centers for resources and expertise.

- Advisory teachers for a range of subjects have been released to work alongside teachers in their own classroom.

Evaluation and research of the impact of the new technology have revealed that there are limitations and constraints, and good practice remains patchy in UK schools.
A cascade model has been used to cope with training large number of teachers. In this model, training starts with the trainers who subsequently train others down the line. Thus, in a relatively short time, simultaneous training can be achieved at multiple sites. It is important to establish feedback and feed-forward loops to monitor guide and guide the process, adapt solutions to problems and inject new knowledge into the system.

**Students, Parents, Community and Business**

Computers are tools of learning. ICT brings students are at the center of the learning experience. Teachers become facilitators of the learning process where reflexive and interpersonal exchanges of information take place. There is more cooperative learning in collaborative work.

ICT brings thrilling experience for students. The world of knowledge is practically at a click away. ICT helps mixed-ability class by providing weaker students with extra practice while more able students explore the lessons further. They get immediate feedback.

Students use computers at home, in schools or community centers. Students who use computers at home are more comfortable to use it at school. In fact they use it more than those who do not have home computers. Mobile computing may relieve students from being in school for long hours.

Students should conform to acceptable use policy of the Internet. Teachers and the school should protect children by enforcing the law, and ensuring that students use technology appropriately and responsibly.
Country Comparison. In Singapore, Offices, shops and homes are being wired for broadband connection. Students and parents can link up to the school. Clearly, the direction is towards a “wired community” (Negroponte, 1985). Similarly, the British National Grid for Learning connects all together. However, the schools need better connection since only 20 percent have broadband. In the United States, it is clearly stated in the Strategic Plan that the school will be integrated with the other parties mentioned above.

Abstraction. Various strategies have been tried to interest parents, communities and businesses in school activities and performance. Parents are involved directly but often do not have the time off to follow their children closely; sometimes communities feel that they are not directly concerned; businesses have a direct stake at properly trained manpower and they donate equipment and fund some activities. To increase the level of active participation in a win-win strategy, ICT has made it possible to connect all three parties with the students through the Internet or networked applications. Parents can help their children with school work, connect and discuss with class teachers; the community can mentor students easily and, in return, can use the school library and network resources; and, businesses can share knowledge, know-how and relevance of educational programs, and can release personnel to help support and train school teachers in literary, technological and scientific skills.

It is easier for parents and the community to hold the school and teachers accountable for teaching and learning. As important stakeholders, they can insist on and help implement safe use policy regarding materials on the Internet. However, there may
be some tension between teachers and businesses as they bear upon assessment, performance and administration.

Research, Evaluation and Dissemination

All three countries are investigating the right pedagogy to maximize learning. In the United States, research is being done in the next generation of ICT systems and applications. There is need to develop cheaper computers and better educational software. Component re-use in lessons will reduce the cost of development.

The technological revolution is ushering dramatic changes in societies. This calls for education systems to adapt to the needs of the future generation. Technologies for teaching and learning have been implemented and used with varying degrees of success. There is need for more and ongoing research and evaluation programs to improve upon the inadequacies of the past and present, and the next generation of technology applications for teaching and learning. For accountability, projects and programs need to be monitored and evaluated. Improvement calls for more research.

A sustained multi-disciplinary collaboration of learning scientists, technologists, subject-matter experts, private and charitable organizations, and the local, state and federal governments, is required:

- To initiate a systematic agenda of research and evaluation on technology applications for teaching and learning in order to improve the state-of-the-art in educational hardware and software, digital content, networked applications, and other technology-related applications of pedagogy and assessment; to effect
comparative studies to benefit from innovations in using technology in education elsewhere in the world.

- To develop assessment tools that evaluate a) content, inquiry and personal student knowledge mastered during hands-on; b) skills in planning how to address a problem, working in collaboration teams, locating relevant and accurate information, drawing conclusions based on data.

- To support the dissemination and use of research-based information to improve teaching and learning through a) regional, national and international conferences seminars and workshops, b) online publications for educators and policymakers.

Cost, Scalability, Sustainability and Future Directions

In regard to cost, the actual cost per student in ICT education varies according to the cost of living and the quality of the infrastructure and service. And it is rarely published. However, England has some interesting data from a 1999 study, see Table 5.8 (BECTA, 2002).

<table>
<thead>
<tr>
<th>Use</th>
<th>Primary</th>
<th>Secondary</th>
<th>Total</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Pounds Sterling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching &amp; learning</td>
<td>11</td>
<td>38</td>
<td>73</td>
<td>per pupil</td>
</tr>
<tr>
<td>Administration</td>
<td>4</td>
<td>8</td>
<td>18</td>
<td>per user</td>
</tr>
<tr>
<td>Personal emails</td>
<td>1.7</td>
<td>8.8</td>
<td>2</td>
<td>per teacher</td>
</tr>
<tr>
<td>Personal emails</td>
<td>0.2</td>
<td>2.7</td>
<td>&lt;1</td>
<td>per pupil</td>
</tr>
</tbody>
</table>
Abstraction. ICT Education is expensive. The initial infrastructure and software, the repairs and maintenance, the supplies, and the periodic renewal of system are costly. This is a prohibitive cost of entry into ICT education for many developing countries (see Chapter 7). However, once the infrastructure is in place, expanding the student base and offering more courses adds low marginal cost. Economies of scale offer huge savings.

Also, the high cost drives technology from the center to the periphery of education experiences. But there is hope that China and India are developing cheap technology via satellite.

Regarding scalability, a project starts on a small scale so that it gives some feedback and it is easily managed until some experience is gathered. In Singapore, there were six participating schools for secondary and another six for primary level. Sometimes, politicians bear pressure to expand the pilot project to include his or her constituency. So in Mauritius the initial five became ten and finally twenty-one for each constituency – in the election year. But the British-Mauritian primary school ICT project started with 6 primary schools until the nationwide program in 2003.

When it is appropriate to scale up statewide or nation-wide, the project becomes a program, and maybe mandated by law. Sustainability is the lifeblood of the program. It needs to be defined properly at the outset for the project or program to survive. For example, Mauritius had received a loan from World Bank to implement a nation-wide ICT education program in primary schools. The infrastructure is being built, equipment purchased and teachers are trained. In five years, the costs of repairs and maintenance
will soar up exponentially. They need to be replaced. Hopefully, the government and the private sector will fund the renewal or the program will come to an end.

There is also another problem. New teachers are being trained to start the program. The other in-service teachers need to be trained for them to integrate technology into the curriculum. There is no provision for it! Finally, the new curriculum materials need to be developed and supported by research and evaluation.

Many ICT education projects had started for prestige but then died when reality struck. This is why we need a strategic compact and good leadership for success.

Looking at future directions, all three countries have invested heavily into ICT to prepare the children for the future technological society that is characterized by increased turbulence. People will change jobs more frequently, and will have to be more creative and innovative and more production of knowledge. There will be more emphasis on just in time learning, lifelong learning and distance learning. Knowledge can be accessed easily from networked resources. There will be less dependence on memory work. The challenge is on new strategies to formulate our needs, know where and how to search for them, choose which resource best satisfies our needs, adapt or create innovative applications. The school needs to adapt quickly if it is to survive as an institution!
Part II: Lens

Framework for Examining ICT Readiness, Needs, Planning and Action Plan

Information and Computer Technology (ICT), has been the driving force behind globalization, which has created new opportunities and challenges. Many industrialized and newly industrialized countries are forging ahead of the information society into a knowledge society and eventually into values-based knowledge society. New developing countries are joining in, in an attempt to effectively enable socio-economic development. This is about wealth creation.

When countries decide to adopt ICT, they can leap forward into the ICT bandwagon, as Mauritius did, with serious consequences, learn from their mistakes and then plan appropriately or they usually create a national ICT taskforce, publish a white paper and obtain consensus from all stakeholders, and develop national ICT strategies into a strategic plan. A strong leadership has a clear vision that is expressed in terms of goals to achieve in the short/medium and long term. The leadership imperative defines ICT as a priority, brings consensus, sustainable investment and a strategic compact. Politics define other factors such as, societal readiness, and social justice, in terms of equity of access and quality, affordability, digital (and gender) divide.

Basically, there are two non-mutually exclusive approaches to Information and Computer Technology (ICT) as an enabler to achieve some selected development goals (e.g., ICT education goals), or an industry focus and integrate ICT strategies into the national development strategies. When undertaken together, they are mutually reinforcing. As a development enabler, it is important to adopt a holistic and multi-
dimensional approach; coordinated actions, strong partnerships and local implementation; and global, national and local linkages.

Integrated Model

Generally, there is a lack of comprehensive frameworks of how to use or deploy ICT development. In 2001, UNDP has put forward a model for ICT socio-economic development that can be used as a development dynamic framework for ICT intervention for synergy and coordinated action of stakeholders, and development impact (undp.org, February 13, 2002). Within the strategic compact that includes vision and leadership, strategic alignment, coordinated action and new collaboration partnership, there are five interdependent key areas of policy, infrastructure, enterprise, human capacity, content and applications, see page 167.

Entry into the framework can be effected at any component level and spill-over effects can be experienced later. However, more components involved the better are the synergies. Beyond the threshold levels of a critical mass, many benefits, like scale effects, network effects, sustainability can be reaped at national level.

The above model will be adopted for the holistic development of ICT in education. The framework lends itself into a lens to focus on the important aspects necessary to carry out a need analysis and develop a strategic plan for a specific country, in particular, Mauritius as a case study (see the next chapter). To the best of my knowledge this adaptation has not been done before.

The components of the framework (see Figure 5.1) are integrated into the human capacity of the super model of the UNDP model (See Figure 5.2).
Components of the Development Dynamic Model
(Accenture-UNDP)

Human Capacity
Knowledge workers
Intermediaries &
technology users
Entrepreneurs

Infrastructure
Relative ubiquity
Strategically
focused capacity

Enterprise
Finance & credit.
Property rights &
commercial law.
Fair tax regime.
Access to global
and local markets.
Efficiency and
reach of local
business.
Demand stimulus.

Strategic Compact
New collaborative
vision and leadership,
strategic alignment
and coordinated
action.

Policy
Transparency and
inclusion.
Regulatory
framework.
Institutional
capacity.

Content &
Applications.
Relevance & usability
Language compatibility
& affordability.
Development
applications.

Figure 5.1. Components of the Development Dynamic Model
Model of Human Capacity in the Components of the Development Dynamic Model

$S = $ Student
$T = $ Teacher
$ICT = $ Information and Computer Technology

Figure 5.2. Model of Human Capacity in the Components of the Development Dynamic Model
At the center is the desired goal of learning, which is affected by the triad of students, teachers and ICT. It is hoped that the new curriculum, revised pedagogy and ICT will eventually maximize learning by increasing the inner inscribed circle in the triangle to the outer circumscribing circle, including the students and teachers in the process of integrating ICT into the curriculum. The restructuring of the school facilitates the fueling of the process. Parents and the community can participate in the school by accessing school resources after school hours; parents can follow at near real-time the children’s performance and help their children with the homework from web-based information; the community can contribute their knowledge, mentoring and assistance where and whenever required by keeping in close contact. Business (the private sector, industry and non-profit organizations) is interested in helping financially, technically and knowledgeably with their staff (social responsibility), and in curriculum relevance because it get its workforce quality from the school that they fund from taxes. Thus ICT enables the synergies of the school, parents and business for the best outcome of student-centered learning. Consequently, the school and the teachers are more closely held accountable for student’s learning – accountability is what the other stakeholders want; here is a source of tension that needs be managed carefully. The teachers require quality training (in-service and pre-service) and support (direct or through distance education) from institutions of higher learning (universities, teacher training colleges/institutes), the school, parents, community, business and the Ministry/Department of Education. The support is in terms of computer systems, supplies, maintenance and renewal of equipment, soft loans for personal computer systems, good library online and offline access, time-off for research and training, and
above all appreciation for their work and a good pay for the extra effort that ICT lessons involved. The heads and personnel of schools, inspectors and other staff need to be trained in ICT literacy for goal congruence.

The whole process needs to be monitored and evaluated in terms of metrics and results; research is needed into the next generation of ICT: easy and friendly computer systems, relevant curriculum and material, effective pedagogy and learning, and management of change. The findings need to be disseminated widely (online). A platform for communications, such as newsletters, journals, workshops, colloquia, seminars and conferences, is needed for the exchange of ideas, innovative techniques and methods, success stories, best practices and problems, and for the promotion of dialogue, building consensus on new agendas at the local, regional, international levels.

The Ministry or Department of Education provides the funding and policy component (that is negotiated among the stakeholders, other Ministries (like Labor, Economic Planning, IT and Telecommunications, Finance, Youth, etc.) and inter-ministerial committees and/or taskforces and the Office of the President/Prime Minister (for vision and leadership) provide the strategic compact. Sustainable funding is the most important contributor to ICT education.

The public and private sectors collaborate in a process that is inclusive, open and participatory. Also the civil societies and international organizations, like UNESCO, UNICEF and World Bank are included. Thus all sectors and stakeholders are involved in the design and implementation of ICT Education. Each group has specific roles and responsibilities at local, national, regional and global levels. Bottom-up initiatives are welcome for scalability and sustainability of local initiatives. New collaborative
partnership between national and international compacts ensures appropriate technology transfer, up-to-date educational training and resources, and sustainable investment.

The sub-model of human capacity calls for harmonious orchestration under good leadership and management. Again, in the larger model all components can fire up the synergies of virtuous cycle of sustainable development. Coordinated action prevents duplication of efforts, achieves synergies, cross-fertilizes ideas, makes multiple uses of ICT infrastructure and functions, and redirects available resources to where they are most needed.

A successful ICT education framework in the human capacity within the dynamic development model will provide the basis for the manpower needed for an ICT industry. Content and applications have to bear the local flavor of language (and font), local sensitivity due to culture. Yet English language is the most common vehicle. More local contents and applications, and their developments, are needed to support ICT adoption.

Broader economic and technology activities, for example, e-government and e-commerce e-learning, ICT industry focus are catalysts for change and adoption of ICT by a large population (massification). The creation of ICT-related jobs will fuel the ICT education and impact positively other sectors.

In sum, the UNDP general component dynamic model of ICT as an enabler has been adopted and the human capacity component has been developed to incorporate a sub-component as a model for ICT education with its own sub-strategic compact but with coordinated action to minimize duplication and re-channeling of resources. The ICT education model has its own synergies within and outside with the components of
the UNDP model. Within this big picture, ICT education development or enhancement can be viewed through the lens of analysis and synthesis as summarized below:

Closing

Just as technology has brought tremendous gains in productivity to the business world, ICT in education has the potential to improve many aspects of education system. To see the benefits of technology, there are a number of conditions that must be in place:

- A technology plan with a commitment to a clear vision and mission.
- Ample access to fully functioning computers.
- High-speed connections to the Internet to take advantage of the power of multimedia.
- Adequate technical support.
- Sufficient support for teachers in their efforts to integrate technology into the curriculum.
- High quality technology professional development.
- Access to the Internet outside the school day.
- Access to technology and curriculum for all students, regardless of abilities.

School districts or the state or country is/are responsible for creating and sustaining these conditions. The authority at the top should facilitate state- or country-wide initiatives and programs to help the sub-authorities implement technology. To help through the process of creating workable technology plans, a set of benchmark standards that can be viewed as goals to achieve by the end of the plan
To ensure that technology is implemented in ways that best align with local and state learning standards, each country needs a technology plan with a realistic and clearly stated set of goals. An important part of that technology plan is the district or state’s commitment to sustained funding for technology through its operational budget.
CHAPTER 6

STRATEGIC PLANNING FOR ICT EDUCATION:
A CASE STUDY OF MAURITIUS

This chapter consists of three parts: Part I deals with a case study of Mauritius while focusing on the issues pertinent to education as exposed in past strategic plans, and their consequent impact on ICT education. Part II presents the application of the framework for the process of strategic planning and needs assessment, which was developed in the previous chapter, and a SWOT (strengths, weaknesses, opportunities and threats) analysis (Mintzberg and Quinn, 1991). The collected data and analysis are embedded in text and support the discussion. Finally, Part III is a strategic plan for ICT education in Mauritian schools.

Introduction

Thomas G. Layton (electronic-school.com, September 20, 2001) argued that the future might be very different from the present, and so we could forget the past and imagine what the future will be for the digital child and work backward to realize the present and devise a strategic plan to lead us from the future to the present. The problem is that relatively long-term future is still in the making, the past did not exist in a vacuum, and its legacies are realities that we have to deal with.

In this chapter, we look back briefly at the historical development of education in Mauritius, picking up some influential forces that we still have to reckon with, and some strengths and weaknesses of past and present strategic plans of education. We look around and ahead for opportunities and threats and situate Mauritius in the
contexts of the Small Island Developing States (SIDS) and in the Newly Industrialized Countries (NICs) for development support from the G8 countries, and for a reference framework with respect to education and training. The NICs of South Asia are successful examples of accelerated economic development models that are different from the West. Lastly, we look forward where we want to be and craft the strategic plan that will take us from here to there in the future.

It is noted that the study focuses on the secondary schools but references to the pre-primary and primary schools are inevitable when dealing with the education continuum. Also, it is logical to refer to that sector, as ICT will be introduced in primary schools in 2003. There are common issues and approaches but different curricula.

**Mauritius and Newly Industrialized Countries**

Mauritius and other NICs have certain similarities. In Mauritius, human resource was developed through free, universal education from primary to tertiary, adult literacy campaigns, population control and free health care. The result is a literate, trilingual and adaptable workforce - the human capital that preceded NIC takeoffs (Bunwaree, 1994). Low labor costs (much less in Mauritius than in Hong Kong or Singapore by 1988 figures) in NICs and labor discipline from material benefits of economic growth (Lamusse, 1982) have contributed to the economic development. The work of Bunwaree (1994) is extensively referred to here.

Often, a favorable conjunction of circumstances and events are conducive to successful economic development. Western Europe during the Industrial Revolution, the New World during the 19th and 20th centuries, and the (NICs) during the 1960s and
1970s. The NICs benefited from unparalleled world economic prosperity for their export markets, especially to developing countries, and from certain favorable relationships due to historical events. Japan helped Korea and Taiwan in agriculture, and China, assisted by United States, used Taiwan’s surplus agricultural produce to finance industrialization (Balassa, 1985). After the Korean War, United States rebuilt Korea and became the major trading partners of Korea and Taiwan. Great Britain, Japan and the United States helped city-states Singapore and Hong Kong to develop as strategic “entrepots” (warehouses) and financial centers while Hong Kong became “China’s window to the West” and, finally, reintegrated China. Mauritius also benefited from “favorable circumstances” due to the instability of Hong Kong and South Africa in transition, and the prosperity of the West in the 80s and 90s (Bunwaree, 1994). Now India and Singapore are partners with Mauritius in building the IT industry.

NICs share many things in common, for example, a deep commitment to education at primary and secondary levels (McMullen, 1982). Hawkins (1989) noted the high education level of the labor forces of the Asian Tigers: In 1983, Hong Kong’s work force had no education (10%), had primary education (37%), and tertiary (19%); and Mauritius’ labor force had primary education (55%), secondary (19%), and tertiary (2-3%). With a lower higher educational level (Bheenick, Hanoomanjee, 1989) than NICs, Mauritians believed that more education and training would help in sustaining economic success. Yet an educated workforce does not guarantee development success, as demonstrated by Argentina, Chile and Uruguay. Confucianism (together with Hinduism in Mauritius) emphasizes secularism, social harmony, achievement and
respect for authority, greatly facilitated economic development in the NICs (Von der Mehden, 1986). In Mauritius, the most important asset is its workforce.

Part I: Case Study: Mauritius

Overview of Mauritius

The country constitutes the main island of Mauritius, the island of Rodrigues, the Agalega Islands and the Cargados Carajos Shoals. The island of Mauritius is fairly developed but Rodrigues is less developed, and the others are sparsely populated. The population of Mauritius is about 1.2 million over 720 square miles of territory and they are descendants from India, Africa, Europe and China. There were no natives. European colonialism (French and English) and mercantile economic forces brought colonists, soldiers, slaves, indentured laborers, traders and professionals in successive waves, resulting in a remarkably diverse mixture of people and cultures (see map in Appendix 6). The diversity is characterized by ethnicity, multiculturalism, multilingualism and multi-religions that have affected the development of education in Mauritius.

Until the opening of the Suez Canal in Egypt, Mauritius was the ‘star and key’ of the Indian Ocean because of its strategic importance on the sea route from Europe to India during the flourishing spice trade of the East India Company. Can Mauritius with its only natural resources being its people and its natural beauty, regain its strategic importance in economic terms? This dream is being realized.

In recent years, Mauritius has been transformed from a sugar plantation economy with high unemployment into a newly industrialized country (NIC) with a
significant immigrant labor in tourism, textile, sugar, financial industries and an emergent Information Technology industry. The economic success of Mauritius has earned her the name of the ‘tiger of the Indian Ocean’ in comparison with the tigers of the Far East.

Information Technology and the emergent technologies hold a promise to help in the socio-economic development of any country. Mauritius is a good example. It has overcome the structural disabilities of SIDS (See Graph in Appendix 4). Although the island, like Singapore and Hong Kong, is classified as a newly industrialized country, it can still benefit as a SIDS for its development from the international community.

It is appropriate to look back at some issues of education, and how the various strategic plans had attempted to solve them. In Part III, the proposed strategic plan for ICT will show how ICT can help solve some of these problems.

Issues

The development of human resource is deeply anchored into the struggle for educational development from disgraceful discriminations under the French and British colonizations to universal free access since 1980. Education is seen as a very important socio-economic ladder.

Primary and secondary education systems have been under fire for a long time. They lack wide consensus and are highly politicized. Governments are at stake! Here is a brief. In 1974, UNESCO study criticized the system and suggested a 9-3-2 year’s system with nine years of comprehensive school (Chinapah, 1983). Various commissions on education, namely, Glover Report 1978 (The Road Ahead) for post
primary and secondary education, Richard Report 1979 on pre-primary and primary education, and Glover Report 1983 (*We've All Been Children*), have identified many problems. The White Paper 1984 outlined the government educational policy that the system must be child-centered, fair, relevant and cost effective, and proposed to improve literacy and numeracy by reforming the primary school curriculum, and to focus on the problems of three languages and widespread private tuition in primary schools. Also, the Paper deplored the wastage of the secondary school system where only one in three students entering secondary schools passed the School Certificate examinations, and proposed technical and vocational education (apparently for the less academically able students (Bunwaree, 1994). The Ramdoyal Report (1990) discussed the issues of language, private tuition and pre-primary sector, and the implications of the UNESCO study, the Master Plan (1991) and other commissions, and proposed the nine-year schooling. The Nine Year Schooling Report (1992) recommends that primary schooling would still be of six years and school leavers would be channeled into either the normal or pre-vocational stream depending on their academic orientation, aptitude and learning preference in order to improve the quality of education and to achieve more equity in the system (Bunwaree, 1994). Again, the White Paper (1997) proposed the creation of middle schools. However, the Action Plan in 1998 polarized the population into two opposing camps and was disfavored by the government. In the Budget 2001-2, the new government devotes 20 percent of the budget to reform the education system to improve quality, access, equity and relevance (ICT education figures prominently in the plan) by building 14 new secondary schools, converting all star secondary schools into high schools, renovating old schools, equipping school
laboratories (with computers also) and training teachers. However, the country is polarized gain in the reverse direction.

The main issues are:

- Mauritian have vital interest in education. Education was limited to the elite of the French and British colonizers' children. Until 1980 when education from primary to tertiary became free, Mauritian struggled for equal access to education and social justice. The struggle has continued for an equitable and good quality education. The present government has initiated important restructure of the educational system.

- Confessional schools. Most confessional schools were founded by priests and nuns and have been of good quality. There are 68 confessional primary schools in Mauritius and Rodrigues. These relatively rich secondary schools have had fifty percent reserved admissions that are being strongly opposed by the population since the state pays for the salary of the staff and the investment on school buildings that depends on the student population. However, they have opposed the inclusion of oriental languages into the CPE examination. These issues have polarized the population at the cost of two changes of governments over issues of the restructure of education. However, the Bureau of Catholic Schools had recently agreed that, under certain conditions, they would participate in the reform process.

- Regional centers of excellence. The elite schools (Ecole du Centre, Ecole Normale, Royal College) under the French and British were centers of excellence that attracted students of the elite colonizers in Africa, Asia, Batavia,
etc. The elite system has dominated educational development, which is presently being democratized. As the country gains more experience in IT, it is possible to build regional centers of excellence, especially in Information Technology and the emergent technologies. (At present, Mauritius is playing a pivotal role in trade in the region).

- Linguistic capital. French is the most popular language and had been the medium of teaching under the French, and even under the British for quite some time. Then English has become the official language and the language of instruction. Yet English is least spoken by the mass. Those who have the linguistic capital have been favored by the system, which may influence a digital divide because the computer language is English.

- Market driven. Mauritius is a capitalist country as it produces commodities for the market (Wallerstein, 1980) but it has no control over its market and hence cannot determine its direction. It strategically offers itself on the market (Bunwaree, 1994). Consequently, the school system is geared towards producing an intellectually skilled elite of human capital for an international market (Bunwaree, 1994). Since the second phase of industrialization, despite the economic success, Mauritius has depended on foreign technology and training as exemplified in 1989 by Minister of Finance Lutchmeenaraidoo “Manpower development is an urgent, expensive and long term process. This is one area where we are seeking cooperation from the industrialized countries. We are not asking for aid but industrialized countries should be able to transfer their technology to us and train our people” (Institutional Investigator, September
1989, p. 15). Sometimes, however, the state intervenes into the free market to correct for gross distortions, as is the case in Singapore.

- Wastage. The failure rates at the Certificate of Primary Education (CPE), School Certificate and Higher School Certificate were 40%, 23% and 28%, respectively (MES, 2001). About 6% are virtually and 20% functionally illiterate.

- Inequity. The low achieving schools (with 30% or less CPE passes) perpetuate a continuing process of low expectations and poor performance (MES Report, 1987). The social environment comprises low income family, malnutrition, least exposure to English and French, no textbooks (secondary), high absenteeism (15-20% primary and 12% secondary students), the school environment of poor sanitation, inadequate desks and chairs, no proper library, etc. – most of the elements to be found on the poor continent of Africa! This situation needs to be addressed properly (earlier programs were not sustainable when the grants terminated). In any ICT program, the state has to address the problem of the digital divide.

- Relevance. Many school certificate and higher school certificate holders are unemployed. Added to this many textile factories are closing down due to higher labor cost and economic downturn. Social unrest is looming ahead. The education system needs to be realigned to match closely the labor market and personal growth. Restructure of the educational system has begun. The state is focusing on solving some of the problems. Hopefully, ICT could contribute to better the system.
Quality. There is a great disparity between the star schools, and the rural and inner city schools. In general, the administration is slow, tolerates private tuition, favors high competition, neglects children with problems and in need of remediation, etc. Some schools need investments and standards. Media glorification of star schools and its yearly laureates give a false perception of the overall performance of its education system.

Excessive practice of private tuition. Most teachers give private tuition to their whole class in their classrooms before and after school, and some during weekends. Those who can afford try to buy individual private tuition or multiple sessions from the best teachers. Thus a free education system in a democratic society becomes, in practice, an elitist system in which results and high quality teaching are on sale for a price. Parents deplore the practice but dare not withhold the advantages from their own children, and the politicians play the game although some palliative attempts have been made (MES Report, 1994). The system engenders great stress on children, parents and teachers, and consequent poor teaching quality in class. The mortality trend in youths aged between 15 - 20 is partly due to lifestyle habits and to the stress on life due to competition in studies and work, the frustration consequent on failures and some general weakening of the family support system in the wake of rapid economic and social changes (Census, 1990).

Restructure. The present government is bold enough to tackle some of the problems of educational reform. To decrease the competition for star secondary schools that distorts childhood with excessive private tuition, most secondary
schools will be up to Form V, new schools for Form VI are being built, regionalization is enforced but parents have the right to choose the school, and ICT will be integrated throughout the curriculum from primary to secondary and vocational/technical schools. New or up-to-date curricula are applied.

ICT can contribute to the restructure process by making learning more fun and effective, improving teaching through (re-) training, facilitating student-centered learning via computers, and improving school administration by decentralizing from MOES headquarters to regional districts and schools, and implementing e-reporting.

• ICT Infrastructure and Training. In 1985, Papayah Guruvadoo, with two colleagues, pioneered computer literacy at Dr. Maurice Cure Government Secondary School. In 1986, he joined the Mauritius Institute of Education and launched the first teacher-training course on IT. The Ministry of Education launched the School IT Project. The first national exhibition and conference on computers were held in August 1987. Subsequent awareness workshops, exhibitions, seminars and conferences were organized for the public, the school staff and the civil service. Computer Awareness led to Computer Literacy, to Computer Studies and to Computer Science throughout the secondary education sector. After a British-sponsored pilot project, the primary school sector will be the target of ICT education as from 2003.

At present, some 300 pre-service teachers are being trained by the Mauritius Institute of Education for introducing ICT into the primary schools in 2003. More training is required for integrating ICT across the curricula. At the same time 350
computer laboratories in 287 primary schools and in the new state secondary will be equipped by networked multimedia systems at the cost of US$53 million (Le Mauricen, 2002).

Strategic Plans for Education 1971-2000

Past strategic plans reflect the problems of the period and the attempted solutions. It is instructive to review briefly the strategies and politics of these plans. After independence in 1968, national strategic plans attempted to address pressing economic and social problems with the philosophy that the promotion and expansion of the relevant kind of education would help to accelerate development and promote economic growth (Bunwaree, 1994). Now, the buzzword is Information Technology industry and the schools are gearing up to accommodate ICT education.

The first national development plan 1971-1975 was inspired from the International Development Strategy that was proposed by the second United Nations development decade, and addressed the problem of unemployment but suffered from lack of up-to-date and relevant data.

The most important resource of Mauritius is its manpower. A well-motivated labor force possessing the requisite mental and physical skills for a modern economy is the most valuable economic asset. While the cultural background and progress of education in Mauritius has provided the basis for an intelligent and adaptable labor force, there is a need to create the skills required to meet the demand generated by prospective economic development. This would require a change in the quality and content of education from its present generally academic emphasis to more technical and vocational orientation at all levels. (National Plan 1971-1975, p. 68)
Successive development plans improved through the findings of various reports (Bunwaree, 1994). The next national plan 1975-1980 was probably inspired by the World Bank’s ‘new’ educational policy with a strong vocational content:

Most of our unemployed people are young, educated and adaptable. With little extra effort they can be trained fairly easily for skilled jobs in industry. A far greater emphasis will therefore be placed on technical education to enable the young to participate in industrial development fully equipped for the skilled jobs which will become available during this plan period. (National Pan 1975-1980, p. iv)

However, the Arab oil crisis led to worldwide recession and local adverse climatic (cyclonic) conditions damaged the sugar crop while declining sugar prices on the international market led to high inflation and unemployment. The interim austerity Development Plan 1980-1982 proposed cost-effective measures resulting in heavy emphasis on vocational education to help solve unemployment but was not successfully implemented (Bunwaree, 1994). It also referred to geographical disparities in education.

The objectives are to improve the efficiency of the school system at all levels, to prepare for self education, to produce various types and levels of skills required for the socio-economic and cultural development of the country, and to improve the existing educational infrastructure and to ensure their more even distribution between rural and urban areas. (National Plan 1980-1982, p.188)

The National Development Plan 1984-1986 attempted to align schooling in line with the world of work and set new objectives:

To adapt the schools to the evolving socio-economic and cultural system of the country, to promote the extension of pre-primary schooling and to provide equal opportunities to all school going children, to explore all means for bringing the educational system into conformity with employment opportunities, and to ensure quantitative and qualitative improvement at all levels and make the system more cost-effective. (National Development Plan 1984-1986, p. 193)
The National Development Plan 1988-1990 was similar to the previous plans except that cultural development was omitted (Bunwaree, 1994).

To bring education more in line with the development needs of the country, to promote the development of science, technology and business studies and encourage research to respond to new demands of a modern economy, to raise the standards of low achieving schools and to make the education system fairer, to mount staff development programmes at all levels to improve the quality of education, to strengthen and stimulate the participation of the community in school life, to increase cost-effectiveness by fully utilising all existing school facilities; and to make the educational system more efficient. (National Development Plan 1988-1990, p. 206)

A consultative approach resulted in the first Master Plan 1991 that hinged on the concept of “Education for All” from Jomtien (Thailand) Conference on Education in March 1990, on manpower training, acquisition of modern high technology equipment and competitiveness for the international market. It recommended the nine-year schooling. The Plan’s spirit was expressed in the following terms:

A major achievement of the system has been that it has provided the greater part of the manpower required for the first stage (labor intensive) of Mauritian industrialisation (p29) … the education system will be called increasingly to provide the intellectual capital, managers, the professionals and the technicians who will be required for the second phase of industrial development (p. 18) … and adjustment process is inevitable and the planning of the education sector is an integral part of the restructuring exercise. (Master Plan 1991, p. 9)

In September 1997, the Ministry of Education and Human Resource published a White Paper on Education that envisioned “numeracy, literacy and computer literacy as pillars of educational wisdom.” “New targets and standards will be introduced with strategies of numeracy, literacy and computer literacy” (p. 3). It laid emphasis on the promotion of Information Technology in education at pre-primary, primary and secondary levels. “Hence the integration of education and human resource development
to produce an adaptable, trainable and educable workforce with the knowledge and skills required to fit in the knowledge society.”

Information Technology is opening the way for every school to have access to a formidable range of resources. Interfacing with the Mauritius College of the Air, the Mauritius Institute of Education and other bodies in Mauritius is but one step to interfacing with the range of sources worldwide...to develop media material and use electronic mailing to assist parents in completing class work. (White Paper on Education, 1997, p.12)

Information Technology Strategic Plan

The first Information Technology Strategic Plan (1992) was an attempt to piece together what was done and needs to be done (a wish list). It was modeled after the British plan but the Mauritian plan did not have the pre-requisites of the British who, for years, have deployed IT through the Micro-electronics Project and Computer Literacy Program.

Also, the strategies were not clear about how to obtain and deploy the resource that were grossly underestimated. The implementation was left in the hands of administrators at the Ministry who knew little about computer education. Teachers trained other in-service teachers at the Ministry. but they did not get required support at school and computer education has remained special subjects (Computer Studies and Computing) at the School Certificate and Higher School certificate examinations. The lack of vision prevented the broader objective of integration of ICT into the curriculum.

Critique

The above strategic plans focused on the human resource, intellectual capital, skills, adapting educational content, self-education, quality, equity, community
participation, culture, cost-effectiveness, promotion of ICT education in schools and a knowledge society. In crafting a new strategic plan for introducing or enhancing ICT in schools, the underlying philosophy should be based on some of the above concepts. The framework that was developed in the preceding chapter ensures a proper analysis and a reliable architecture of the plan. Above all, the leadership determines the success of the plan.

It is noted that there was a tendency to align the earlier strategic plan on to current world themes of education. Later, they became more responsive. However, success was not always easy for various reasons. For example, the Information Technology strategic plan (1998) was a mere wish-list without any evaluation. It is pertinent to note wishful thinking, lip service and rhetoric in the various plans, which had focused on human resource development and adapting schools to evolving socio-economic needs of the country. Also, translating strategic plans into actionable plans have been wrought with serious difficulties of implementation.

Over the last twenty-five years, the impressive achievements in education have been pivotal to the country’s socio-economic development. In short, there are universal and compulsory primary education (5–2 years of age); minimal gender disparities (girls doing better) due to free primary, secondary and tertiary education (White Paper, 1994); extensive infrastructure for provision (50% after independence in 1968); and teacher training and supervision. However, compared to NICs, the Mauritian education indicators are lower. To sustain the country’s growth as it moves into the more service-led, skill intensive and knowledge economy, it has to dig deeper into the problems of education that is socially explosive and economically threatening.
Part II: Applying the Framework

The framework that was developed in the preceding chapter is applied to the case of Mauritius for the needs assessment.

Socio-Economic, Political, Cultural and Technological Factors

Economy

The Mauritian economy rests on four pillars, namely, tourism, textile, sugar and finance. The major contributors are the first three but the fourth is growing fast with the offshore banking and increased trade with Africa. The next burgeoning sector is Information Technology.

The Growth Domestic Product (GDP) represents productivity and, indirectly, the capacity for social expenditure such as education. In 1999, it grew by 8.6% in real terms; GNI (Gross National Income) per capita at current market prices increased by 9.0%; and the education sector grew by 6.4%. But the investment ratio (Gross Domestic Fixed Capital Formation (CDFCF)/ GDP) at market prices in 2000 dropped from 27.6% (1999) to 23.7%. The economic growth rates for 2000 and 2001 were 8.6 and 6.3 percent, respectively (CSO, 2001).

The share of the private sector in total CDFCF in 2001 is expected to be 68.6%. The private sector is small but vibrant and very entrepreneurial. Also, it operates in Madagascar, Mozambique, India, etc.

With rapid economic and technological changes, there is a need for a more flexible and skilled manpower. The economic challenges facing the Mauritian export-
Driven economy with trade liberalization and the removal of protectionist barriers through the World Trade Organization have given a new thrust to human resource development for competitive positioning. Education and training play a very important part in the development.

**Education**

For the financial year 2001/2002, government recurrent expenditure on education was estimated around US$142 million. This represents 15.3 % of the government total recurrent expenditure of $933 million (Economic and Social Indicators, 2002). Most of the capital expenditure was used to build 11 new secondary schools, and laboratory equipment, including computers.

The distribution of some school indicators and budget by educational sector provide data on students, teachers, deputy/head-teachers/rectors, administrative staff, students-teacher ratio and percentage of the budget for the different sectors of education (see Table 6.1).

**Table 6.1**


<table>
<thead>
<tr>
<th>Sector</th>
<th>Schools</th>
<th>Teachers</th>
<th>Non-teachers</th>
<th>D/Heads</th>
<th>Adm</th>
<th>StudTotal</th>
<th>S/T</th>
<th>%Budget (recurr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preprimary</td>
<td>1,090</td>
<td>2,441</td>
<td>743</td>
<td></td>
<td></td>
<td>38,340</td>
<td>16</td>
<td>1.5</td>
</tr>
<tr>
<td>Primary</td>
<td>293</td>
<td>5,379</td>
<td>2,952</td>
<td>1,141</td>
<td>293</td>
<td>134,085</td>
<td>34</td>
<td>31.8</td>
</tr>
<tr>
<td>Secondary</td>
<td>136</td>
<td>5,302</td>
<td>2,674</td>
<td>211</td>
<td>764</td>
<td>97,647</td>
<td>18</td>
<td>39.9</td>
</tr>
<tr>
<td>Tech/Vocational</td>
<td>59</td>
<td>305</td>
<td></td>
<td></td>
<td></td>
<td>4,919</td>
<td>16</td>
<td>1.9</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.7</td>
</tr>
</tbody>
</table>

Sources: (CSO, 2001), (Economic and Social Indicators, 2002), (Budget, 2000-2001).
Pre-primary and primary schools catch most of the children since primary schooling is compulsory. The Gross Enrollment Ratio (GER) (number of children attending an education sector as a percentage of the total number of children in the age group for that sector) was 96%. The GERs for primary and secondary schools were 100% and 63%, respectively. The pupils:teacher ratio is high (34:1) in the primary but elsewhere it is acceptable. There are 1,352 deputy and head teachers/rectors and 1007 employees supporting the school administration. The education budget favors the secondary level (39.9%) because of the urgent need for qualified manpower although more money needs to go to the primary level for better returns on investment.

The pre-primary and secondary schools are mostly privately owned (79% and 75%, respectively) but the primary schools are mostly state-owned (80%).

Gender is an important issue. The gender distribution of students and teachers (except pre-primary) for 2000 – 2001 is fairly balanced (see Table 6.2).

Table 6.2

<table>
<thead>
<tr>
<th>Sector</th>
<th>% Girls</th>
<th>% Female Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-primary</td>
<td>49</td>
<td>99.9</td>
</tr>
<tr>
<td>Primary</td>
<td>49</td>
<td>N/A</td>
</tr>
<tr>
<td>Secondary</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>Vocational</td>
<td>31</td>
<td>49</td>
</tr>
</tbody>
</table>

Source: Economic and Social Indicators, 2002
N/A: Not available.

Female teachers are good role models for girls. Again, in terms of overall performance at public examinations in 2000 - 2001, females do consistently better than males.
Table 6.3

Performance at Public Examinations by Gender

<table>
<thead>
<tr>
<th>Public Examinations</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>CPE (at age 11)</td>
<td>14,449</td>
<td>61</td>
<td>13,614</td>
</tr>
<tr>
<td>SC (at age 16)</td>
<td>NA</td>
<td>78</td>
<td>NA</td>
</tr>
<tr>
<td>HSC (at age 18-20)</td>
<td>3,152</td>
<td>77</td>
<td>3,350</td>
</tr>
</tbody>
</table>

Source: Economic and Social Indicators, 2002.

(Key: CPE = Certificate of Primary Education, SC = School Certificate, HSC = Higher SC. The SC and HSC examinations are held by Cambridge University in England.)

It follows that, given equal opportunity, there is no basis for a gender divide in IT. However, the reality is different in Form IV and above where IT courses are optional. The pass rates for Computer Science at HSC for 1995-1997 were 87.0, 87.9 and 90.9 percent, which were high (breakdown by gender was not available) (MES, 1998).

The school system is characterized as elitist (Bunwaree, 1984). The competition is fierce as the intake for secondary schools is based on performance. However, this system will be changed to a region-based intake into secondary schools in 2003. The system is plagued by private tuition from the early years of primary to the end of secondary level.
Politics

The country has a long history of democracy and the republic is modeled after the British parliament. In general, there is stability, which attracts investors. The source of occasional instability is political. The government runs on a political alliance of minority groups.

Pre-primary schools are partially funded (about 30%) and the rest of the education system up to the university level is free. However, free education is a burden to the state. The private sector and the middle class parents form a powerful force and keep the government hostage from any reforms! The good schools perpetuate the middle class and above. Later the same pattern continues in higher education. The University of Mauritius is state funded and is highly competitive. Students who can afford go abroad for further studies.

Actually, reforms in schools are highly politically charged, so much so that two governments lost in pre-termed general elections. However, enjoying a comfortable majority, the present coalition government is carrying on reforms according to its electoral manifesto.

Society

There has been much progress in terms of social justice that has brought a practically free universal education. Parents value education and sacrifice a lot to get their children a good education as failing in the system is equivalent to being relegated to hard labor and poor pay. The elitist system poses equity problems. Government expenditure per student varies greatly between state and private schools thereby
differentiating schools in terms of facilities, namely, buildings, laboratories, libraries, and qualified teachers.

This brings equity issues also in ICT education. State schools (which are good schools in general) and some good private schools have the best-equipped laboratories, and they attract the most qualified students. Some private schools abstain from ICT because it is cheaper to run a non-ICT class than to offer ICT courses (they are paid in terms of the number of students). Some incentive schemes like matching grants for equipment in private schools usually attract investors who are convinced of the benefits of ICT education. Particular attention must be paid to the digital divide.

Culture

The population is multilingual and multicultural. In the small island, there is more social cohesion but islanders look overseas. Many Mauritians travel overseas, study abroad, and return to work at home. Everyone is exposed to satellite media and there are some 30 daily/weekly publications. Colonization by the French and the British had brought in technology and developed the island. Cultural ties exist between Europe, United States, Africa, India and China. Mauritians are exposed to ideas, inventions and technology with the result that the latest developments in technology, fashion, etc., in Europe, United States or Asia are soon adopted at home. Hence, with a literacy rate of 80%, there is a readiness to adopt ICT.

With the collaboration of India, the country is launching the IT industry and creating a “cyber-city” to integrate all services. Singapore and Malaysia are partners, too. Hence, the job market will be attractive. This will bootstrap IT education, and vice
versa. There is also a good but small research community which excels in some areas, like sugar technology. The private sector is thriving and is open to international cooperation for strategic alliances for technology transfer.

Technology

The country moved from a mono-crop sugar economy in the sixties to a manufacturing base and a service industry (tourism and finance). From sugar to textile factories and other manufacturing industries, Mauritius has asserted itself as a NIC. Now, the new venture is ICT.

It is well connected to the world by a network of air and sea transportation, electronic cables and satellites but has yet to liberalize its telecommunications industry. Internet access is still expensive but there is a cheaper school rate with, unfortunately, limited number of hours. There are no custom duties on imported computers, parts or software.

There is a package of incentives for ICT investors, like pioneer status company registration for tax exemption and 70 percent of training costs are refunded, etc. There are no custom duties on computer systems to encourage ICT penetration into households, schools, businesses and the community.

Contextual Factors, Metrics and Statistics

The contextual factors and indicators that are useful to consider for ICT education in Mauritius are shown in Table 6.4 below. The statistics are derived from primary data or extracted from official publications.
<table>
<thead>
<tr>
<th>Factors</th>
<th>Metrics</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area</td>
<td>Population density per square mile</td>
<td>1.2 million over 720 sq. miles = 1667 inhabitants per sq. mile</td>
</tr>
<tr>
<td>Family units</td>
<td>No. of households</td>
<td>290,000 households</td>
</tr>
<tr>
<td>Youth</td>
<td>Youth (&lt;25 years old)</td>
<td>Estimated at about 28% out of school</td>
</tr>
<tr>
<td><strong>Socio-economics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economy</td>
<td>Gross Domestic Product (GDP) per capita</td>
<td>8.3% in 2000, 6.3% in 2001.</td>
</tr>
<tr>
<td></td>
<td>Free market</td>
<td>Mostly free with few mixed markets from government’s interference to correct distortions.</td>
</tr>
<tr>
<td>Culture</td>
<td>Diverse</td>
<td>Multicultural, multilingual (English and French are main languages).</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>High rate of technology diffusion, adoption, and adaptation.</td>
</tr>
<tr>
<td>Society</td>
<td>Freedom of expression</td>
<td>Free, liberal</td>
</tr>
<tr>
<td>Education</td>
<td>Educational level</td>
<td>High basic education (almost 100% primary education). ICT literacy is moderate. Adopted ICT education at secondary level. Population is ICT-trainable.</td>
</tr>
<tr>
<td>Digital divide</td>
<td>Household ICT density</td>
<td>21% with PC, 90% TV, 100% radio. Urban (24% PC), rural (18$ PC), (68% households intend to buy a PC. (92% of PC owners intend to have Internet. (Household usage of IT Survey Oct. 2000).</td>
</tr>
<tr>
<td></td>
<td>Internet access rate.</td>
<td>8% with Internet.</td>
</tr>
<tr>
<td></td>
<td>Community ICT density</td>
<td>1 PC connected to Internet at each social center (65), public libraries (10). About 10 PC per Internet cafes (12).</td>
</tr>
<tr>
<td></td>
<td>Youth (&lt;25 years old) out of school who are potential ICT users.</td>
<td>Estimated at 16%.</td>
</tr>
<tr>
<td></td>
<td>Senior citizens with access to computers or Internet (at home)</td>
<td>Estimated at 2%.</td>
</tr>
<tr>
<td></td>
<td>% of girls taking related ICT courses at schools.</td>
<td>Estimated at 46%.</td>
</tr>
</tbody>
</table>

Continued, next page.
Table 6.4, cont’d.:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Metrics</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITC Readiness</td>
<td>Telephone density</td>
<td>76%</td>
</tr>
<tr>
<td></td>
<td>DSL access</td>
<td>1 company services business over cable; leased lines, international broadband connections via satellite &amp; marine cables.</td>
</tr>
<tr>
<td></td>
<td>Internet access rate</td>
<td>12% at work, Internet Cafes, schools, social centers</td>
</tr>
<tr>
<td></td>
<td>Internet users</td>
<td>73.4% (per 1000 inhabitants)</td>
</tr>
<tr>
<td></td>
<td>No. of Internet hosts</td>
<td>2.71% (per 1000 inhabitants)</td>
</tr>
<tr>
<td></td>
<td>No. of ISPs</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Type of service</td>
<td>digital over microwave, optical cable, telephone</td>
</tr>
<tr>
<td><strong>ITC Park</strong></td>
<td>% of schools using computers.</td>
<td>39 out of 1100 (); 1 or 2 PCs 100%;</td>
</tr>
<tr>
<td></td>
<td>Pre-primary</td>
<td>1 to 3 PCs (100% state schools; 15 PCs in lab., 2 PCs in lib., 2 PCs in offices)</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>70 out of 91 private schools have variable number of PCs.</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>65 out of 151 have PC labs. And offer IT. 406 courses including 172 awards.</td>
</tr>
<tr>
<td></td>
<td>Vocational &amp; technical</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>No. of computers per classroom</td>
<td>33:1 (state sec. schools); higher for secondary schools</td>
</tr>
<tr>
<td></td>
<td>Students/computer ratio.</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>Private</td>
<td>10% (1:5) for people aged 5 and above.</td>
</tr>
<tr>
<td></td>
<td>% of classrooms w/Internet</td>
<td>2 PCs in each library in state schools.</td>
</tr>
<tr>
<td></td>
<td>Internet access rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(% of) machines connected to Internet</td>
<td></td>
</tr>
<tr>
<td><strong>Quality of hardware</strong></td>
<td>At least Pentium PC</td>
<td>Grade A (Pentium III, multimedia): 50%</td>
</tr>
<tr>
<td></td>
<td>Multimedia, possible Internet connection or equivalent (Mac).</td>
<td>Grade B (486 microprocessor):30% Grace C (8088, commodore, BBC) 19% Other (Mac) 2%.</td>
</tr>
</tbody>
</table>

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Table 6.4, cont’d.:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Metrics</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of software</td>
<td>MS Office. Educational software for various subjects, micro-worlds simulations</td>
<td>100% office productivity tools. 80% Logo 3% schools have educational software.</td>
</tr>
<tr>
<td>Time usage</td>
<td>Hands-on hours</td>
<td>1 ¼ hours per week class practice = ¾ hr./week/pupil in F1-III state schools</td>
</tr>
<tr>
<td><strong>Human Resource</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT professionals</td>
<td>No. of ICT professionals per 10,000 people</td>
<td>7.5 IT professionals, 7.8 supporting IT staff</td>
</tr>
<tr>
<td>ICT Usage</td>
<td>Curriculum relevance</td>
<td>ICT skills (or technology and information literacy skills – TILS)</td>
</tr>
<tr>
<td>Instructional usage</td>
<td>Instruction hours</td>
<td>1 1/3 hours (F1-III) 2 2/3 hours (FIV-V); 5 1/3 hours (FVI Lower and FVI Upper)</td>
</tr>
<tr>
<td>Coverage</td>
<td>Number of subjects involved using ICT specialist courses</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Across curriculum</td>
<td>Computer Literacy (F1-III) Computer Studies (FIV-V) Computing (FVI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insignificant; individual teachers’ efforts.</td>
</tr>
<tr>
<td>Teacher availability</td>
<td>Students:teacher ratio</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>16</td>
</tr>
<tr>
<td>Teacher workload</td>
<td>No. of contact hours</td>
<td>5.5 hours per day; now 6/5 hours per day. 20 hours per week 20-25 hours per week</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocational &amp; technical</td>
<td></td>
</tr>
<tr>
<td>Trained teachers</td>
<td>% of ITC-trained</td>
<td>Most lack confidence to teach ICT general teachers across curricula.</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>Since 1998, 100% pre-service teachers</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>Since 1999, 100% in-service Postgraduate certificate teachers</td>
</tr>
<tr>
<td></td>
<td>% of specialist teachers</td>
<td>100% trained specialists for IT (F1-V)</td>
</tr>
<tr>
<td>Head/Directors</td>
<td>% of ITC literate</td>
<td>Short introduction to ICT for administrators</td>
</tr>
<tr>
<td></td>
<td>Headmasters/Rectors/Inspectors</td>
<td>ICT Inspectors (3 months intensive training)</td>
</tr>
</tbody>
</table>

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Table 6.4, cont’d.:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Metrics</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>ICT administrative support/usage</td>
<td>Some word processing and spreadsheet applications (All school clerks need ICT retraining)</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Library &amp; publications</td>
<td>100% qualified.</td>
</tr>
<tr>
<td>Research &amp; Evaluation</td>
<td>No. of quality (publishable) research papers on ICT Reports Assessment</td>
<td>Less than 1% 5% 52%</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Workshops, seminars, conferences</td>
<td>5%</td>
</tr>
<tr>
<td>Community</td>
<td>% of parents’ knowledge of ICT % of Members of the family conversant with ICT</td>
<td>46% ICT aware 20% ICT literate 5% ICT proficient 30% ICT literate</td>
</tr>
<tr>
<td>Business</td>
<td>ICT usage ICT expertise</td>
<td>90% of businesses 31%</td>
</tr>
<tr>
<td>Senior citizens</td>
<td>Usage of ICT</td>
<td>1%</td>
</tr>
<tr>
<td>Other out-of-school youths and adults</td>
<td>Usage of ICT</td>
<td>18%</td>
</tr>
<tr>
<td>Cost Model</td>
<td>Cost per ICT student per year</td>
<td>Variable, depending on infrastructure, software, and qualified teachers.</td>
</tr>
<tr>
<td>Student</td>
<td>Primary</td>
<td>N/A</td>
</tr>
<tr>
<td>Teacher</td>
<td>Secondary</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Cost per ICT teacher per year</td>
<td>Variable, depending on infrastructure, software, and qualified teachers.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Primary</td>
<td>Project (50% from UK government) From 2002, 100% funding from World Bank</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>100% funding for state schools; 50% funding for private schools.</td>
</tr>
<tr>
<td></td>
<td>Vocational &amp; Technical</td>
<td>Employer’s fund and private investment.</td>
</tr>
</tbody>
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<thead>
<tr>
<th>Factors</th>
<th>Metrics</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensibility</td>
<td>Primary schools</td>
<td>Yes. 100% funding for coverage. Need to train large number of teachers.</td>
</tr>
</tbody>
</table>

Infrastructure, Information and Content Management

In 2000, the school infrastructure in each of the 34 state secondary schools includes a laboratory housing 15 standalone computers and two printers. The hardware is mostly Pentium III multimedia PCs with Windows 98 but there are still some 486 machines with Windows 95. The printers are dot matrix and inkjet. In the 91 private schools, only 74 have computer laboratories that have been equipped with matching grants from the state. The 10 confessional schools have fully equipped laboratories and 6 of them operate local area networks.

They all have word processor WORD, spreadsheet Excel and database DBASE III Plus that were bundled together free of charge on purchase. There is a copy of old LOGO that does not run on Windows but on DOS, and a few other disparate programs that were probably pirated and copied illegally. There is no licensed educational software.
There is a meager budget for stationery (less than $200), which is often inadequate for repairs and maintenance. Also, each school offers a limited number of hours (maximum 20) per month of Internet access. Sometimes the laboratories are reserved for higher examination-oriented classes. The selective access is a cause for concern with respect to the digital divide. In the private colleges, some costs (up to $67) per year are borne by parents or covered through fund raising activities. The students consider the fee to be high compared to the expenses!

School libraries have one (in private schools) or two (in state schools) Internet connections. Students book slots of time to use the computers or make requests of their needs and the library staff do the search according to Guruvadoo’s Post Office Model (Guruvadoo, 1999). The limited access to Internet at school favors those who can afford additional Internet access at home or in Internet Cafes. Inadequate hands-on exposure will negatively impact the quality of the students’ experience of ICT.

All communications in the educational system are done through snail mail or the telephone. There was an attempt to set up an Educational Management Information Systems, which has died in the pipeline. Parents receive the term reports, which have subjects, corresponding and overall grades and a laconic statement of one or two words. According to school cultural differences, Parents- Teachers’ Associations are strong in confessional schools but are generally weak in state primary and secondary schools.

All primary schools have a standard general curriculum. As from 2003, the ICT curriculum for primary schools will be adapted from the one in use in United Kingdom. All state secondary schools have a standard ICT curriculum but private schools adapt the common curriculum to their needs and technology availability (learning with
technology at the periphery). The secondary curriculum is inspired from the syllabuses of externally examined ICT courses.

There is free flow of contents from the Internet. With floating windows of undesirable materials taking over the computers, some form of content management is highly desirable. Filters or pre-selection and posting on the web through an educational network may be necessary to block objectionable materials, protect national interests against undesirable materials and reconcile conflicting cultural values in information contents (according to 82% of parents; 70% of rectors; 68% of teachers; 21% of students).

There are some locally produced contents, like a digital map, arts and culture, history, environmental science, etc., on CD-ROMs. They need to be encouraged and supported. Teachers and students’ excellent projects could be burned in on CDs and/or put online for diffusion.

There is also the need to enforce intellectual property rights, privacy and data protection, security, etc., which are not observed at school and to a large measure in the country. Probably an alliance with Microsoft could provide a cheap license package for schools, and students as well as teachers would learn a lifetime lesson of copyright.

There is need to lower significantly telecommunication costs although there is a cheaper educational rate ($0.03 per minute) than the commercial one.
Distance Education and Virtual Systems

Distance education lessons are carried out in a mixed mode of snail mail and electronic media, which include the radio, television, networked computers, teleconferences (rare) and Internet.

All tertiary institutions operate a mixed mode of distance education in order to cope with the demand and reduce the cost of face-to-face delivery. In strategic alliances with Napier University (Scotland) and University of Brighton (England), many teacher trainers at the MOESR and the Mauritius Institute of Education have been upgraded to Post-graduate Certificate in IT or Master’s level in Education. Similarly, the teachers in schools could be trained if MIE or the Mauritius College of the Air (MCA) could partner with some virtual institutions from abroad for the teacher education in ICT. Through audio and video and mixed mode, MCA has offered distance education in a number of fields. In strategic alliances with Indira Gandhi Open University in India, Lawrencian University in Canada, and other universities in France and Australia. MCA offers award and non-award courses leading to certificates, diplomas and degrees in Information Technology and other subjects.

Private tuition is practiced on a large scale and affects education in Mauritius. MCA is implementing the Net School based on Guruvadoo’s design to provide help to students in order to reduce their dependence on private tuition (Guruvadoo, 1999). Also, private enterprises cater for secondary school subjects, and offer tuition at a much lower cost than live individual or group sessions. Local institutes or business schools offer distance professional courses through mixed mode.
Virtual systems may be expensive in capital outlay but once the system is up and running, extensions to the system over space is negligible. As they provide flexible learning, many full-time employees and students can benefit from them. However, there are issues of quality assurance.

Teacher Education and Training

ICT professionals are a scarce resource all over the world. State funded University of Mauritius, University of Technology in Mauritius, Swami Dayanand Institute of Management, MIE, MCA, and private institutions are offering certificate, diploma, degree and higher degree courses in IT, they will not be capable to cater for the present demand of 1900 and the projected demand of 13,000 IT professionals in 2006 (ncb.intnet.mu, May 5, 2002).

By 2003, there will be 10, 500 teachers to be trained to teach 285,000 pupils in pre-primary (40,000), primary (130,000), secondary (90,000), and vocational (15,000) and technical schools (ncb.intnet.mu, May 25, 2002). Up to now, specialist teachers have been trained to teach specialist ICT courses and computer literacy in lower secondary schools. In most primary schools there are about two to three teachers to teach ICT awareness. But to implement teaching with computers across the curriculum to enhance learning is a different matter. Teachers need more training in pedagogy, instructional design and content development for the new environment of student-centered learning. They need to feel confident to teach with technology across the curriculum. And they need more computers.
Evidently, there is a major lack of capacity in publicly funded institutions to cope with the exponential demand by extending coverage to all schools and focusing on enhancing learning through ICT throughout the curricula.

Given proper incentives, the private sector can intervene to deal with such a huge demand. Part of the solution is through mixed mode distance education.

Educational Institutions, Restructure, Curricula and Renewal

Educational curricula need to be updated at regular intervals, especially at significant phases, to reflect the real needs of the world of work, society and personal development. In an elitist system of educational, few schools excel but most have been ineffective and inefficient. Only 3.5% of Certificate of Primary Examination (standard VI) candidates are admitted to star secondary schools and expect future success while 32.1% fail and are bound to low-paying jobs or unemployment. The remaining 66.4% are milled through the secondary schools with 33% failure at School Certificate and/or 20% failure at Higher School Certificate examinations (ncb.intnet.mu, April 15, 2002).

Reforms are initiated to democratize the educational systems and decrease wastage. More secondary schools are being built, up to 48 by 2005, to reduce the rat competition at CPE level, which destroys childhood and stresses the parents. The new seven-year secondary schooling will be split into middle schools (FI-V) and Form VI schools. Regionalization is in force in 2003 and parents can exercise their choice of schools within the region (ncb.intnet.mu, April 15, 2002).

ICT will play a more prominent role in schools. Computer laboratories are redesigned and equipped properly with local area networks and Internet connections.
Specialized computing facilities will be available in Form VI schools. As from 2003, through a loan from India, every primary school will have a laboratory of twenty networked computers.

There is need for integrating ICT into the curriculum, and for more computers, multimedia laboratories, educational software, curriculum redesign and training for teachers.

There is scope to modernize operations by decentralizing the bureaucracy of MOESR and communicating through ICT to keep tighter virtual control from the Ministry through the regional school districts to the schools. For improved efficiency and effectiveness, school administration should communicate to the Ministry and the community, and vice versa, to promote e-governance. School reports could be made available online, and lesson plans and schedules could be put on the web to teachers' collaboration and involve parents in the daily work and performance of their children.

Parents, Community and Business

At present, parents are involved in schools through the parents-teachers' associations (PTAs). Except in confessional schools, PTAs are generally dormant. There was an attempt to introduce community school boards but the plan never worked.

The school can be virtually extended to reach the parents, local businesses and the larger community. Members of the community can be trained in ICT literacy on school computer facilities and use the Internet after school hours. In the hope of benefiting from appropriately trained manpower and exercising their social responsibility, businesses can offer some of their trained personnel and old computers to
school. This closer relation will benefit school for resources and funding, and require
accountability from the school as demanded by the private sector. However, the danger
of deformation of the school curricula by business needs to be watched by the school
and the broader community.

Students and Learning

As reported above in the section “Educational Institutions, Restructure,
Curricula and Renewal”, the high wastage in the school system means that learning is
not effective (ncb.intnet.mu, April 15, 2002). Students need to be engaged in learning.

Users aged 12-20 years are interested in using the computer and the Internet for
emails/chat, news, information, download papers, programs and listen to music, play
games and distance learning. Communicating and seeking information are learning
processes that enrich their knowledge. Internet Cafes thrive from their quests but this is
still expensive.

The few computers available in schools and the high demand being placed on
them practically give students little hands-on experience. They research their materials
from the Internet by proxy library staffs. However, those who have computers and
Internet connections at home are better off. By increasing the size of computer parks at
school, in the libraries and community centers, the digital divide can be bridged. Also,
by giving fiscal incentives like income tax deduction, exemption from sales tax, flexible
loans, and/or lower telecommunication charges, more households can own computers.
As we move deeper into the Information Revolution and the use of ICT, the synergies
and multiplier effects would sweep more people into the whirlpool of ICT users.
Research, Evaluation and Dissemination

There is a lot of lip service about research. The truth is that most researchers at MIE (the research arm of MOESR) are not trained to do research. Many studies are invalidated by factors that are not considered. The situation has slightly improved by the Master's course in Education from Brighton University, UK. But this mostly distance education program cannot foster the rigor of research that can usually be done by studying and working with researchers.

MIE and the Ministry should decentralize much of the research practice to pilot schools in the five regional school districts (two primary and two secondary schools in each district) under the umbrella of NCICTE. These schoolteachers would experiment and assess their results or practice in pedagogy, instructional design, curriculum materials, use of educational software, etc. They could pre-select educational materials from the Internet that could be indexed and made available online. They could develop educational software with local contents. The MIE and the Ministry could guide, and support these teachers, coordinate their activities and evaluate the research before disseminating their work to a wider teaching and learning community. Connection with other researchers and teachers in the world is important to share relevant world knowledge.

There is a need to conduct conferences, seminars and workshops to bring ideas, issues, best practices through guidelines and standards, and achieve consensus on some important topics, and also to disseminate the results on paper or online documents through the community. There is need for a good website to bind and catalyze research interests.
SWOT Analysis

Looking at the Present

A SWOT (strengths, weaknesses, opportunities and threats) analysis is an exercise to look inward at the past and present to know our strengths and weaknesses, to look outward by scanning the environment to find out the opportunities and threats to the organization (Mintzberg and Quinn, 1991).

Strengths

Human capacity. To produce an intelligent, educable and trainable workforce. We can retrain qualified unemployed young graduates in ICT (India’s approach to the IT industry).

Resourcefulness. The people have picked up successfully past challenges in agriculture (sugar technology is one of the best in the world), industrialization (textile industry competes successfully on the European and US market), tourist industry (high-end tourism) and financial industry (offshore banking bridges the East and Southeast Asia, and Africa).

There is a vibrant private sector with know-how and technology transfer experience and entrepreneurship. It has attracted financial direct investment by entertaining strategic alliances with the East, West and South-South. A right package of fiscal and financial incentives will galvanize action. A partnership of public and private sectors and the civil societies will synergize to make ICT education and ICT industry successful.
Synergy. There are collaboration structures for ICT between the Ministry of Informatics and Telecommunications (MIT) and the Ministry of Education and Scientific Research (MOESR). MIT operates the National Computer Board for planning, evaluation and policy research; the Central Informatics Bureau for the public sector computerization and procurement; and the Central Computer Systems Division for data processing. The Ministry of Education and Scientific Research has under its aegis three publicly funded universities and twelve private tertiary institutions offering ICT courses leading to diplomas and degrees, in addition to the Mauritius Institute of Education for teacher training, and the Mauritius College of the Air for the learning channel (distance education). MIE and MCA can train the ICT graduates of higher education to teach in schools. Also, certain changes in the Education Act can empower private institutions can participate in the training of IT manpower. Recently, other players have joined in: Satyam International, University of Mauritius (with Indian collaboration) School of Advanced Computing, etc.

Experience. ICT education has been around for the last 16 years in secondary schools, and for 5 years with primary school teachers. The experience in teacher training, project implementation and scaling up to national implementation is valuable. It might be applicable partly to the primary sector, which has its own challenges. There is a small thriving IT industry on the island.

Infrastructure. Semi-governmental telecommunications company, Mauritius Telecoms (MT), strategically partners with France Telecom PC. It has been investing steadily in modernizing the telecommunications infrastructure, although the field needs to be liberalized (MT has a monopoly) to bring in competition and lower the cost of
communications. A competitor could partner with the Ministry of Education to offer more services and free Internet connectivity for education in return for a broad community client base of households, schools and businesses.

There is a computer laboratory in all state secondary schools and in 70 out of 91 private secondary schools. All new secondary schools to be built will have computer laboratories. All (287) primary schools already have 1 to 3 computer systems.

Electric power, telephone (wired, cellular and microwave) and transportation are readily available throughout the island. Fiber optical cable, which is capable of broadband transmission, runs through two-thirds of the main road artery along the island. Oceanic fiber optic cable SAFE connects Mauritius to Europe via South Africa, and to the United States via Malaysia. There are also satellite communications with London and East Coast Unite States in one hop.

**Funding.** There is an Employers’ Fund, which is created from a levy of 1% private sector turnover for industrial training. Pioneer-status-oriented companies benefit up to 70% refund for training of their personnel. The state has imposed an increase of 3% sales tax to finance school reform. Couple with new opportunities in ICT and an exponential demand for training, international and local companies have move into ICT training and production.

In 2001, India has loaned Mauritius over $3.3 million dollars to launch ICT education and ICT industry. India has a bilateral agreement to build a cyber-city in Mauritius.

**ICT Culture.** An ICT culture has been created over the last fifteen years. There is a general awareness about computers. All Form I-III students are computer literate.
Yearly vendor exhibitions, conferences, seminars, workshops keep the professionals, students and the mass in touch with developments. Broadcasting ICT programs on radio and television reach people in their home. Newspapers, magazines and journals about IT are widely available but costly. (Singapore has a focus on IT culture).

**Popular Support.** There is a great interest in ICT from students, parents, non-school population, business, and politicians. Parents are eager that their children learn the new technology that the job market demands and offers good opportunities. Children love to experiment, learn and play with computers. Youth want to communicate and search for information. Enabled workers use computers for shopping, work and communications. Business use computers as a productive tool and for e-commerce. Thus, politicians have all the necessary ingredients for a popular program of development.

**Weaknesses**

**Supply of IT Specialists.** There are few IT specialists in Mauritius. The ICT industry will need 19,000 IT professionals by 2006 and the education sector will need to train over 10,000 teachers in ICT integration in school curricula by 2003. This is a staggering task (nceb.intnet.mu, May 5, 2002).

IT specialists are in great demand in the world. The local private sector or industrialized countries could poach them. They need better compensation to keep them in the country. This will escalate costs and create labor tension.

**Political Interference.** Politicians want to include the schools within their constituencies. This may affect the size of the pilot project. In the Mauritian context, the
original size was 6 but eventually became 34 (all state secondary schools), which became a burden). (Singapore maintained 6 for primary and 6 for secondary schools).

**Digital Divide.** A large percentage of students at (especially private) schools will have no or insufficient access to computers and to the Internet as the telecommunications rate is still expensive. Lack of access may compromise ICT education as being ineffective.

**Intellectual Property.** There are intellectual property laws that safeguard copyright laws but they are not properly enforced, thus undermining software and media productions, and foreign investments.

**Investment.** ICT education requires massive infrastructural investment if we choose ICT to be central to learning. Insufficient funding may move ICT to the periphery of learning, which may compromise invaluable hands-on experience for innovative and creative learning. The Mauritian economy, which is very dependent on foreign markets, may affect investment.

**Opportunities**

**Wealth Creation.** ICT is an industry of the future that is capable of generating great wealth and be able to support development objectives. Investing into proper ICT education will prepare the future labor force with the necessary skills to be innovative, creative and adaptable to the digital world. The possibilities are virtually unlimited. There is a high rate of return on investment, as the extension of computing projects requires marginal costs.
Strategic Alliances. Long cultural ties and bilateral agreements contribute to India’s support and investment in the Mauritian IT industry, including ICT education and training. Singapore, European Union and United States are working with the state and local stakeholders to promote the ICT industry and education.

Employment. There are many unemployed university graduates who are a potential source of instability for the state. Just as the textile industry has provided massive employment opportunities for the semi-skilled women, in the same way the ICT industry will provide most jobs for the skilled professionals.

Restructure. Until 2001, reforms in the education sector have been cosmetic. The new government has pledged to restructure education and introduce ICT at all levels. To produce resourceful, innovative and creative people, the Ministry of Education and Scientific Research has to restructure schools, train and retrain teachers to teach confidently with computers, that is, to integrate ICT into the curricula, implement new learner-centered pedagogy, train the administrative staff to use ICT, introduce assistive technology to support students with special needs, and to bring the community closer to the school by sharing the resources of the community and the school. The restructure will increase efficiency, productivity and accountability of the school, and communications with parents, business and the community.

To decentralize schools from the ministry to school district levels and make them more autonomous and responsive to the community needs while maintaining tighter control on resources and performance results at MOESR. The technology makes remote transactions transparent and in near real-time.
Distance Education. To develop distance education to deliver online courses and broadcast audio and video courses to support teaching, and to provide flexible learning for capacity building and lifelong learning.

Enrichment. Curriculum materials, lesson plans, methodology and best practices can be easily shared online, thus de-isolating and connecting the teachers to their professional network. The students can work collaboratively with remote students of the world on diverse projects and languages thus widening their experience and knowledge of the world.

Threats

Competition. There will be strong international competition in the race to wealth. Brainpower will pay. The education system needs to be good, and hence the pressure to restructure the system to achieve high quality output.

Security. The industrialized countries and NICs have invested heavily into ICT education and are major producers of ICT. Some developing countries have made significant progress but others cannot afford the technology. This digital divide within and between countries is a menace to world security. Through lack of investment, systems security is foregone, thus exposing the vulnerabilities to hackers.

Culture. The push technology over the Internet can bring into the country undesired and pornographic materials which might kickback the positive contribution of ICT in education and undermine the local culture.
Recession. A system of education that hinges on expensive technology is at the mercy of the international money markets. Maintenance of aged computers or renewal of technology is costly. Sustainability of ICT education is at stake.

In designing the strategic ICT plan, we will seize the opportunities and build on our strengths, work on our weaknesses and minimize the threats. The vision is where we want to be, and the mission is the business that we are in. To achieve our vision while practicing our mission, we define the goals that will take us from the present to the future where we want to be. This is Part III below.

Part III: The Strategic Plan

By looking at our past and present, we take stock of our strengths and weaknesses and, by looking around and ahead, we learn of the opportunities and threats. The strategy will be to build on our strengths, fortify our weaknesses, take on the opportunities and minimize the threats. The vision is based on what and where we want to be. The mission defines the business that we are in. The goals are the strategies that will take us from the present to the future while realizing our goals.

Vision

To build a cyber Island to provide a competitive, environmentally safe and modern economy and society through Government shared vision of improving the quality of life of its people.
Mission Statement

To leverage ICT to contribute to increased opportunities for all students to engage in challenging and meaningful learning experiences, and to provide the youth with the skills that are needed in the knowledge-based society.

Goals and Strategies

Goal 1

To provide leadership, funding, sustainability and strategic compact. Strategies:

1. To provide leadership imperative, define the vision and mission.
2. To appoint a powerful person who has charisma, can inspire and lead the nation, mobilize the resources, streamlines laws and regulations, and contracts strategic alliances with local and overseas partners in the private and public sectors.
3. To set up task forces for specific areas under the chairperson of the Minister of Education.
4. To raise money and provide continuous funding.

Goal 2

To provide schools access to computers and connectivity. Strategies:

1. Computer hardware, networking and the Internet. To construct, enhance computer laboratories, virtual classrooms, and office automation, and connect them through a local area network to the Internet. The school local area network will connect to a wide area network that is supported by a
backbone of fiber optic cables that runs almost length-wise across Mauritius (like the East-West 190 Mass Pike Fiber Optic cable). Eventually, Reduit-Moka campuses of higher education will have a backbone connected to the Cyber City at Ebène, and this backbone will be extended East–West. Similarly, lengthwise backbone will be extended further north and further south. This high-speed network will support broadband multimedia applications for education, public administration and business, and will open quality access to global information. Connectivity will increase communications, access to information and collaboration.

2. Equipment life cycle: Procurement, replacement and recycling. To streamline procurement process and shorten turn-around time to respond flexibly to needs. This process should be decentralized from the Ministry of Finance to the Ministry of Education and to the new National Center for Information and Computer Technologies in Education (NCICTE), and to the regional education centers and eventually to schools. NCICTE will provide online guidelines for the purchase of technology. School computers need to be replaced cyclically (every two years in Slovenia). Equipment ages with an active life of 3 to 5 years, and maintenance increases exponentially with age. Thus, school computers are kept up-to-date with little maintenance overhead (the vendor provides warranty for one year), and the displaced machines can be sold to teachers and students at a reduced price (30% of cost price in Slovenia) or can be used in the offices. However, this scheme is costly and depends on assured funding. An interesting alternative (from Taiwan) is to
train high school or vocational school students (or prisoners for free) to do
the maintenance and repairs and recycle give-away computers from
business. This scheme has the merit of training future manpower and
obtaining low-cost services. Students can receive a stipend or practical
experience that may be counted towards an appropriate course.

3. To procure and develop software. To provide schools with educationally
appropriate and up-to-date software. Generally, Windows 98 and beyond,
and office productivity software (word processing, spreadsheet and
database) should be made available to all schools. (Maybe, a strategic
alliance Microsoft could support this initiative (as in Slovenia,
(educa.fmf.uni-lj.si, October 23, 2001)) in return for observance of
intellectual property rights. There is a great need of educationally
appropriate software to use across the curriculum. To develop software
locally in order to preserve the cultural heritage and specificities across
mathematics, languages, arts, and local literature. To give incentives to local
businesses to involve teachers and students in the production of software and
local media content. Teachers and students can develop projects using
multimedia authoring systems, and after evaluation, the projects can be made
available on-line from NCICTE website. To use audio and video-conference
to virtually attend major events, lectures, debates, etc.
Goal 3

To provide students (and teachers) with an innovative and creative learning environment that increases performance and opens up to the world. Strategies:

1. To increase access to computer systems and connectivity. To subsidize computers (eliminate custom duty (done), remove sales tax and give tax relief. To create an affordable or education rate for Internet (E-Rate) or as, all expenditures are born by the State, provide for school children free Internet usage 24 hours per day over 7 days per week. This can be realized through some strategic alliances between the Ministry of Education and with (Government controlled) Mauritius Telecoms Company (as in Estonia) and some vendors who can package reasonably priced computers. To give all students and teachers free email accounts. To provide teachers with free email accounts at home with free or subsidized notebook (Singapore’s model).

2. To provide schools with educationally appropriate and up-to-date software.

3. To engage in collaborative projects with other schools, and other countries. They can study languages, social sciences and sciences by sharing materials, data and pictures and communicating via email. This is a fun way of increasing communications and exchange, and opening up to world knowledge, leading eventually to a global consciousness.

4. To acquire information literacy through the use of computers and the Internet. To evaluate one’s information needs, search for them, select
matching or near-hit information, repackage the information and present it effectively for peer review or use in real life projects.

5. Above all, to make learning flexible, easier, more fun and more effective.

6. To build a center of excellence in ICT education for teaching and learning for the African region.

Goal 4

To provide teachers with training, support and resources to create and innovate to learner-centered pedagogy and curriculum materials, and integrate ICT into teaching across the curriculum, and ICT as a specialist course. Strategies:

1. To train pre-service and in-service teachers through a cascade model (trained teachers train other teachers) to increase the number of teachers required as soon as possible. Pre-service teachers are easier to train properly in student-centered pedagogy. However, in-service teachers are more difficult to change from the old teacher-centered to new student-centered pedagogy but they have valuable experience that can be transferred to creative work. To provide support to teachers until they feel confident to teach the ICT as a subject and to help them integrate ICT into the curriculum by employing technical assistants and well trained teachers who can support computer systems repairs and maintenance, and teach specialist ICT courses and integrate ICT into the teaching of other subjects.

2. To encourage teachers to work collaboratively with their students in project work and with their colleagues in sharing data and teaching notes, search for solutions, prepare for the class, and attend continuing education courses,
seminars, etc. ICT takes more of the teachers' time and they should be compensated by time off or extra remuneration.

3. To give incentives to teachers to own their computers for better access and productivity. Subsidize computers and Internet rates or give them free access at school and at home (like in Singapore). This will help develop curriculum material with local adaptation.

4. To create a technology team at each school to foster an ICT culture. The team comprises the stakeholders at the school level, including the opponents to ICT education.

5. To provide a flexible learning environment in mixed mode delivery to improve professionally at subsidized rate or free of charge through lifelong learning, distance education and e-school (Mauritius College of the Air). Part of the training (content) maybe through distance education and the practical or philosophical part through direct contact.

Goal 5

To restructure the school organization through training and ICT applications.

Strategies:

1. To train the administration: Inspectors Head-Teachers, Rectors, Principals, to facilitate and manage the deployment of ICT in schools, and the administrative staff to work in a computerized environment and communicate electronically through emails and e-forms with the Ministry of Education. This will greatly improve communications and decrease the turn-
around time for correspondences (which now takes up to three months).

Also, by using the school LAN as an intranet with Lotus Notes, internal communications will be greatly improved, and a school Web page will connect parents, business and sponsors, and the rest of the community to bring synergy and accountability in the school system.

2. To decentralize the activities, like budgeting, expenditure, reporting, enforcement of rules and regulations, etc., to regional offices (5) and schools, thereby creating more responsible governance. Yet, through the use of ICT, there is a tighter control over the above activities, and grades, absenteeism of students and teachers, and overall performance that can be monitored closely by regional offices and the Ministry of Education.

3. To train the directors of the schools and the national inspectorate to be leaders, mentors, facilitators, fund-raisers, advocate in the community, agents of change, etc., in the restructuring process of education. (Often, principals of schools has been hampered ICT education he because of ignorance, lack of ownership and training).

Goal 6

To carry on research, evaluation, standardization and development. Strategies:

1. To create a National Center for Information and Computer Technologies in Education (NCICTE). This center will oversee, evaluate and help develop the research in pedagogy, curriculum materials and appropriate educational contents over the Internet. It will also enforce intellectual property rights,
manage digital contents and knowledge over the Educational Network. CICTE will issue standardization guidelines to implementing schools.

2. To create ten research-based schools (RBS) (Estonia’s model), two in each school district for primary, and ten more for secondary schools, under the umbrella of NCICTE, MIE and MOESR. They will hire very able teachers who will experiment with new methodology and curriculum materials and ways to integrate ICT into the curriculum. The best practices will be disseminated to all implementing schools.

3. To develop local content, curricula and new assessment standards. With the participation of the private sector or civil societies, they will stimulate the development of local software through multimedia authoring systems, and benchmark the products for review by NCICTE before widespread diffusion and adoption. With the collaboration of the Mauritius College of the Air and the Mauritius Broadcasting Corporation, NCICTE will ensure a powerful vehicle for transmission of teaching videos or digital media.

Goal 7

To expand access and the use of the information infrastructure to the community, including parents and business. Strategies:

1. To equip libraries, community centers, community technology centers, youth centers, senior citizen centers information kiosks with ICT.
2. To implement e-government. People can search for information, download forms, and make payments, access schools to check lessons and progress of their wards.

Goal 8

To develop on-line support for educational development, including distance education and lifelong education. Strategies:

1. To develop access to knowledge sources. Students and teachers should be able to access educational material on-line through e-libraries. To-date, the main libraries are putting their collections of book titles and summary online. We need to access the online contents of magazines, journals, reports, newspapers, some books and broadcast images. We also need to negotiate access rights with digital libraries overseas. CICTE will partly pre-process documents of educational value, index them and make them accessible through hyperlinks at NCICTE’s site or mirror them to their schools’ sites, thereby decreasing the cost of operations.

2. To provide seminars, workshops, conferences, exhibitions on ICT. This is a platform to exchange ideas, explore the models of practice, bring consensus, disseminate findings and network with colleagues with similar interests.

3. To develop an effective distance education to reduce private tutoring that is expensive and time-consuming. Mauritius College of the Air should partner with international organizations to use and develop interactive software that could be downloaded on to PC’s asynchronously, for example, the OWL
system (umass.cs.edu, April 30, 2001). To facilitate access to computers, school computer laboratories should be open after school hours.

Goal 9

To provide support for the physically and mentally challenged students.

Strategy:

1. To provide access to schools and access to ICT through the use of assistive technology, for example, Braille printers and voice recognition software that translate their verbal documents to text or the screen-based texts to voice.

Timeline for Implementation

An implementation plan over three stages of short, medium and long-term phases are sketched below in Table 6.5.

Summary

Chapter 6 dealt with a Mauritius as a case study and was presented in three parts. Part I examined the main issues of education in Mauritius as exposed by the previous strategic plans followed by a critique of the way the plans had attempted to solve the problems identified. Part II contained the classical SWOT analysis followed by the application of the framework for ICT readiness and needs assessment that was developed in Chapter 5. To the best of my knowledge, the contextual indicators that
Table 6.5

Timeline for Implementation 2003-2007

<table>
<thead>
<tr>
<th>Goals</th>
<th>Year 203</th>
<th>Year 204</th>
<th>Year 205</th>
<th>Year 206</th>
<th>Year 207</th>
</tr>
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<tbody>
<tr>
<td>Leadership &amp; strategic compact</td>
<td>1</td>
<td></td>
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<tr>
<td>School ICT Infrastructure</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>Teaching and Learning</td>
<td>3</td>
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<td></td>
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<td></td>
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<tr>
<td>Training Teachers</td>
<td>4</td>
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<tr>
<td>Training Administration</td>
<td>5</td>
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<td></td>
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</tr>
<tr>
<td>Research, Eval. &amp; Diffusion</td>
<td>6</td>
<td></td>
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<td></td>
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<tr>
<td>Access to community</td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td>On-line &amp; Distance Ed</td>
<td>8</td>
<td></td>
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<tr>
<td>Assistive Technology</td>
<td>9</td>
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</tbody>
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| Major Evaluations              |          |          |          |          |          |

have been used here are new tools. The results emerged as a vision and a mission, and a set of goals and strategies. The application of Ethnographic Delphi Futures Research (EDFR) methodology, as described in Chapter 3, yielded a consensual strategic ICT education plan. Finally, a timeline for implementation was included.
CHAPTER 7

CONCLUSION

This chapter opens up with a summary of the study and ties the various pieces together. It includes a reality check of answers to questions, which were posed in Chapter 1, including the strategic plan for ICT education in Mauritius and a timeline for implementation. There are also sections on implications, personal experience, recommendations and future directions. Finally, question 4 is answered in the section, *ICT Transfer to Developing Countries*.

Summary

We have found that education and, consequently, ICT education, in a given country is a function of the political, economic, social, cultural and technological dimensions. All industrialized countries, all newly industrialized countries and some developing countries, as well as small islands economies, had developed or adopted ICT in education with some variations. For the scope of this study, we focused on three country case studies, namely, Singapore, United Kingdom and United States. However, whenever there were some compelling examples from elsewhere, they have been added to the analysis and synthesis, which yielded a framework with contextual factors and a set of metrics. This resulted in a lens that served to examine any country’s readiness, needs and strategic planning for ICT education. The author developed the human capacity component from the UNDP model for ICT development (undp.org, February 13, 2002) as an integrated model for ICT education. The above research was applied to a case study of Mauritius as a test bed in terms of a strategic plan for ICT education for
the period 2003 – 2007. Finally, the lens is tweaked to find some pathways to transfer ICTs in education to developing countries, in particular to Africa.

It is only in the last four to seven years that most governments have expressed any ambitious strategy for stimulating and supporting the use of ICT in education. A clear picture of the wide-ranging benefits of ICT is emerging: effective use of ICT can enrich and enhance all aspects of schooling – teaching and learning, management and administration, linkage between school and home, community and business, and above all students’ achievement. In the past, there were criticisms but they were mainly due to inadequate access, inappropriate and costly equipment and educational software, poor accommodation in the school, lack of close pedagogical support to teach either ICT as a specialist course or ICT applications across the curriculum, lack of confidently trained teachers and school personnel, and inappropriate curricula. Since the advent of multimedia, networking, Internet and the Web, friendly and visually powerful graphical user interface (GUI), multitasking operating system, authoring packages with teacher’s instructional design, reasonably cheap personal computers, notebooks and printers, computer systems have become easily adaptable tools for educational use. Also, recent researches into pedagogy, learning, a new generation of educational software, more effective teacher training and disseminating excellent policy and practice have renewed confidence in ICT use in education. Further, the active involvement of students-teachers-parents-community, government and schools partnership with business and non-profit organizations, are providing sustainable funding and investment to promote ICT education. However, some teachers still feel uncomfortable at integrating ICT into the curriculum. Still others resist the technology. The problem is not so much about
hardware or software but peopleware. More research is needed to adapt the pedagogy to teaching and learning.

Putting It All Together into a Conceptual Model

Within a broad typology, the role of ICT can be characterized as either a production sector or as an enabler of socio-economic development (undp.org, February 13, 2002). Within these overall approaches, there are strategic choices, which influence particular policies and strategies. Four types of neither non-mutually exclusive nor necessarily complementary interventions are identified: export market focus, national capacity/domestic market focus, global positioning and development goals focus, which contribute to building a framework to guide our understanding. The framework consists of five components: infrastructure, human capacity, policy, enterprise, and content and application (undp.org, February 13, 2002). Around this framework, ICT initiatives can be implemented strategically “to ignite, accelerate and sustain a network of positive effects of the virtuous cycle of a sustainable development dynamic” (undp.org, February 13, 2002, p. 14).

The component of human capacity of the UNDP model was developed by the author in this study into an integrated model to deal with education and training (see pages 167-168). Both formal and informal education take place within the model but the focus of this study is in the formal education sector. The central aim is to increase the learning experience of the student with the teacher and the support of ICT. Learning opportunities are facilitated beyond the school virtual extension to reach out to the parents, community, business and other resources to become eventually a school
without wall. Teachers are properly trained by universities, which deploy some of its resources in terms of research, links and pedagogical support to schools. Policies and professional practice are negotiated on a common platform of conferences, workshops and seminars, and the successful results are disseminated widely. Changes in the curriculum, pedagogy, ICTs, management, school environment and its external linkages for relevance and funding call for continual review and restructure. Finally, the Ministry or Department and/or the State provide(s) the leadership imperative, sustainable funding and support, including rewards for best performances.

Questions & Answers

Question 1

What are some important current issues in education, and how can ICT address them? In particular, how can we use ICT to restructure the educational environment to maximize educational benefits?

A lot of attention has been given to the above questions and the answers have been discussed in chapters 1, 2, 5 and 6. In Chapter 1, the background and the problem statement introduced the main issues in education, and the possibility of ICT contributing towards solving some of them and restructuring the educational environment for maximizing educational benefits; Chapter 2 provided the theoretical foundations to the issues, the educational environment, the process of restructure, planning and some of the resulting educational benefits; Chapter 4 presented three country case studies and their attempts to
answer the above questions; In an analysis, synthesis exercise, Chapter 5 discussed the solutions to the above questions in the light of Chapter 4; and Chapter 6 answered the questions for the case study of Mauritius.

IT has changed the real world so fast that the school has lagged behind and needs to restructure. There are new tools, richer contents and more effective methods available in this present age of ubiquitous computing.

The issues were:

- Relevance of curricula with respect to the world of work and personal development of children in the present and future.
- Infrastructure for ICT in education. Networked classrooms connected to the Internet.
- Extension of school to home and the community and to the world through Internet.
- Tackling the issue of equity and digital divide.
- Implementation of research findings on effective learning and sound teaching.
- Continuation of research on pedagogy as the technology advances.
- Teacher training and confidence in integrating ICT into the curriculum.
- Improving management and administration of schools.

ICT supports access to richer contents, powerful presentations in multimedia, lesson plans, networking, communications and collaborative work.
Question 2

What is an appropriate framework to analyze and make a needs assessment of ICT education? Can we develop a lens to be used to plan ICT for other countries?

1. In order to plan for a particular country’s ICT education, we need to collect and analyze data, using a framework to facilitate the evaluation of the country’s readiness and needs. This framework, with the contextual factors and a set of metrics, was developed by the author, and is summarized in terms of the following:

   Strategic Compact, Politics, Economy, Society and Culture.


3. Data and Metrics.

4. Information Infrastructure.

5. Infrastructure (hardware, networks, computers, software and Internet).

6. Distance Education and Virtual Institutions.

7. Educational Institutions, Restructure, Curriculum and Renewal.

8. Learning.

9. Teacher and Administrative Staff, and Education and Training.

10. Students, Parents, Community and Business.


12. Cost, Scalability, Extensibility and Future Directions.

   To minimize the complexity of a flow-chart of decision-making, the above framework is reduced to a basic framework in terms of the following:
1. Leadership, funding/investment, private sector and strategic alliances
2. Organization
3. Infrastructure
4. Contents and curriculum
5. Teacher and administrative staff training
6. Research, evaluation and dissemination. (See Figure 7.1 for flow-chart.)

The framework together with the contextual factors, the set of metrics and the flow-chart of decision-making, serve as a lens that can be applied to a country intending to introduce or enhance ICT education.

Question 3

What is an appropriate strategic ICT education plan for Mauritius? What have been the main issues in education in Mauritius? What is the needs-assessment in terms of ICT education?

The framework and lens were applied to the case study of Mauritius. The consensus and ownership in terms of goals and strategies of the plan were realized by using the Ethnographic Delphi Futures Research (EDFR) model (Cogan and Derricott, 1998).
Figure: 7.1. Flowchart for decision-making from the basic conceptual framework.
The resulting strategic plan for 2003 – 2007 is summarized in Table 7.1.

**Vision**

To build a cyber Island to provide a competitive, environmentally safe and modern economy and society through Government shared vision of improving the quality of life of its people.

**Mission Statement**

To leverage ICT to contribute to increased opportunities for all learners to engage in challenging and meaningful learning experiences.

**Goals and Strategies for Implementations.** The goals are realized through strategies that are implemented at the strategic, tactical and operational levels. For goal coherence, clear communications in terms of feed forward and feedback are important to all members of the team.

**Timeline for Implementation**

An implementation plan over three stages of short, medium term and long-term phases is sketched below (see Figure 7.2).
Table 7.1

Goals and Strategies for Implementation

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategies</th>
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<tbody>
<tr>
<td>1. To provide leadership, funding, sustainability and strategic compact.</td>
<td>To provide leadership imperative, define the vision, mission, and goals.</td>
</tr>
<tr>
<td>2. To provide schools access to computers and connectivity.</td>
<td>1. To provide computer hardware, networking, and the Internet.</td>
</tr>
<tr>
<td></td>
<td>2. To attend to equipment life cycle: procurement, replacement and recycling.</td>
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<tr>
<td></td>
<td>3. To provide educational software.</td>
</tr>
<tr>
<td>3. To provide students (and teachers) with an innovative and creative learning environment that increases performance and opens up to the world.</td>
<td>1. To increase access to computer systems and connectivity.</td>
</tr>
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<td>2. To provide schools with educationally appropriate and up-to-date software.</td>
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<tr>
<td></td>
<td>3. To engage in collaborative projects with other schools, and other countries.</td>
</tr>
<tr>
<td></td>
<td>4. To acquire information literacy and computer fluency through the use of computers and the Internet.</td>
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<td></td>
<td>5. Above all, to make learning flexible, easier, more fun, and more effective.</td>
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<td>4. To provide teachers with training, support and resources to create and innovate to learner-centered pedagogy and curriculum materials, and integrate ICT into teaching across the curriculum, and ICT as a specialist course.</td>
<td>1. To train pre-service and in-service teachers through a cascade (fan) model (trained teachers train other teachers) to increase the number of teachers required as soon as possible.</td>
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<td>3. To give incentives to teachers to own their computers and to connect to the Internet for better access and productivity.</td>
</tr>
<tr>
<td></td>
<td>4. To create a technology team at each school to foster an ICT culture. The team comprises the stakeholders at the school level, including the opponents to ICT education.</td>
</tr>
<tr>
<td></td>
<td>5. To provide a flexible learning environment in mixed mode delivery to improve professionally at subsidized rate or free of charge through lifelong learning, distance education, and e-school (Mauritius College of the Air). Part of the training (content) may be through distance education and the practical or philosophical part through direct contact. It will also serve students and serve as an alternative to private tuition.</td>
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### Table 7.1, cont’d.:

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategies</th>
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</table>
| 5     | 1. To train the school administration: Inspectors, Heat-Teachers, Rectors, Principals, to facilitate and manage the deployment of ICT in schools, and the administrative staff to work in a computerized environment. A school Web page will connect parents, business, and sponsors, and the rest of the community to bring synergy and accountability in the school system.  
2. To decentralize the activities, like budgeting, expenditure, reporting, enforcement of rules and regulations, etc., to regional offices (5) and schools, thereby creating more responsible governance. Yet, through the use of ICT, there is a tighter control over the above activities, and grades, absenteeism of students and teachers, and overall performance that can be monitored closely by regional offices and the Ministry of Education. Also to create responsible e-governance.  
3. To train the directors of the schools and the national inspectorate to be leaders, mentors, facilitators, fund-raisers, advocate in the community, agents of change, etc., in the restructuring process of education. (Often, principals of schools have hampered ICT education because of ignorance, lack of ownership, and training.) |  
|       | 1. To create a National Center for Information and Computer Technologies in Education (NCICTE).  
2. This center will oversee, evaluate and help develop the research in pedagogy, curriculum materials and appropriate educational contents over the Internet. It will also enforce intellectual property rights, manage digital contents and knowledge over the Educational Network. NCICTE will issue standardization guidelines to implementing schools.  
3. To create ten research-based schools (Estonia’s and Singapore’s models), two in each school district for primary, and as many for secondary schools, under the umbrella of MIE and MOESR and NCICTE.  
4. They will employ very able teachers who will experiment with new methodology and curriculum materials and ways to integrate ICT into the curriculum. The best practices will be disseminated to all implementing schools. |
| 6     | To carry on research, evaluation, standardization, and development. |
Table 7.1, cont’d.:

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategies</th>
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<tbody>
<tr>
<td>To expand access and use of the information infrastructure to the community, including parents and business.</td>
<td>5. To develop local contents, curricula, and new assessment standards. With the participation of the private sector or civil societies, they will stimulate the development of local software through multimedia authoring systems, and benchmark the products for review by NCICTE before widespread diffusion and adoption. With the collaboration of the Mauritius College of the Air and the Mauritius Broadcasting Corporation, NCICTE will ensure a powerful vehicle for transmission of reaching videos or digital media.</td>
</tr>
<tr>
<td>To provide support for the physically and mentally challenged students.</td>
<td>1. To develop access to knowledge sources. Students and teachers should be able to access educational material on-line through e-libraries. To date, the main libraries are putting their collections of book titles and summary online. We need to access the online contents of magazines, journals, reports, newspapers, some books, and broadcast images. 2. We also need to negotiate access rights with digital libraries overseas. 3. MCA will develop flexible and asynchronous distance education to promote lifelong learning and reduce private tutoring, which is expensive, exploitative, and time-consuming. 4. NCICTE will partly pre-process documents of educational value, index them, and make them accessible through hyperlinks at its site or mirror them to their schools’ sites, thereby decreasing the cost of operations. 5. NCICTE, with MCA, will evolve into a regional center of excellence in ICT education for teaching and learning. 6. To provide seminars, workshops, conferences, exhibitions on ICT.</td>
</tr>
</tbody>
</table>

237
**Question 4**

How could the above model be adapted in a technology transfer to developing countries, in particular to Africa?

**ICT Transfer to Developing Countries**

The motivation to focus on Africa is to limit the scope of the study and deal with the poorest continent on earth. Also, Mauritius is geographically, historically and politically close to Africa; it entertains increasingly large trade relations; and, it is looked upon as an emergent center for excellence in business, education, health and IT. Actually, what is developed here is transferable to any developing country,
In this section, we look at developing countries through the lens that was developed in Part II of chapter 5 and used as a test-bed in the case study of Mauritius in chapter 6. First, I present the role of enabling sectors, like the non-governmental organizations, industry, telecommunications, academic and research institutions, and international organizations. Then facing the realities of the developing countries require tweaking the framework and focusing on the pertinent components of the framework that are applicable to emergent economies and possibly to poor countries.

Digital Divide and Dividend

Most industrialized countries and newly industrialized countries (NICs) in South East Asia, Latin America and South Africa, and some developing countries, including some small states economies (SIDs), have embarked on ICT education, thus impacting pedagogical, technical, economic or social factors. The least developed countries of Africa, Latin America and Asia are severely handicapped by the need for more basic teaching and learning resources. At the colloquium for Creating Digital Dividends, William Ruckelshaus, the President of World Resources Institute claimed that eighty percent of world population has never handled a telephone, and that 100 millions users are connected to the Internet which represents less that two percent of the world population (vnunet.fr, November 6, 200)

On the one hand, the emergent economies have developed some initiatives to introduce ICT in schools but the poor countries, like in sub-Saharan
Africa, have no formulated policy for introducing the new technologies into education at primary or secondary level, with existing efforts being concentrated in the area of higher education, as reported at the Second International Congress UNESCO on Education and Informatics (Moscow, 1996). The poor countries argue rightly that they need basic necessities to survive. The personal computers are too expensive for the majority of Africans. The telecommunications infrastructure and electricity exist in the big cities and, probably, in the suburbs, at an exorbitant price and are practically inexisten outside the cities.

On the other hand, for the sake of peace, humanity and eventual payback in terms of broader trade, the industrialized economies and the newly industrialized countries need to bridge the digital divide by using their digital dividend through ICT to help the poor countries to break the cycle of poverty, connect the people with the outside world and give the youth a chance to be educated, creative and innovative in their search for development solutions using ICT. This is one of the biggest challenges of the new century.

Generally, poor countries have to cater for other basic priorities. Most of the initiatives of ICT in education in Kenya and Zimbabwe (Bloome, 2000), other parts of Africa, and elsewhere in the world, have, at least initially, been from private, not-for-profit institutions or donor agencies. They introduce the seeding effort. Often in the past, the initial project was devoid of sustainability. Now, formal educational ICT is sustained by providing equitable access to ICTs outside a formal educational framework, to the wider community with a proposal for the establishment of multipurpose community centers for universal

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access to a range of services meeting community needs, with information
technology as the backbone (undp.org, February 13, 2002). Where the initial
projects have fructified, there are ongoing basic awareness of computers and
maybe limited computer applications by incorporating them into other subjects.
The digital divide is rampant in selective offering of ICT courses.

Avenues for Cooperation

Hawkridge et al. (1989; 1990) observed that where there were no state
policies or action taken, other sectors of society would nevertheless bring ICTs
into the education system and might well serve to shape any future policy-
making in this domain. Recent state-led policy approaches in some countries are
actively seeking to involve these other significant actors, e.g., World Links of
World Bank, in decision-making processes and strategies for developing ICT
use in education. In industrialized countries, corporate industry and commerce,
and academic and research institutions have played a leading role in this respect.

There are four enabling sectors for the promotion of ICT in education,
namely, non-governmental sector, industry, academic and research institutions,
and international cooperation.

Non-Governmental Organizations

This sector has played an important role both in industrialized countries,
such as the USA during the 1960s and 1970s, when commercial firms or private
schools led the way in bringing computers into the lower education system, and
in numerous developing countries today, where donor agencies, multinationals and parents have all contributed to providing schools with the new technology.

**Industry**

The theme paper of the Information Society and Development Conference (1996) stated that even in developing countries, the private sector should be primarily responsible for financing the development of the information society. I would add that the state should contribute to the major infrastructure development. Actually, major international telecommunications are selling telephone infrastructure to African countries.

Apart from its funding role, industry has much to contribute in terms of technical expertise, whether assisting schools in designing suitable educational software, or publishing guides such as the *Education Technology Toolkit*, designed by Apple Computer to provide both developed and developing countries with essential information about the application of computers and related technologies in schools (Hill, 1989).

However, the involvement of such groups and their influence on policy and practice should be seen as being far from neutral or incidental, all having some particular interests in the impact of the technologies on the educational process. The "market driven" interests of industry are likely to be at odds with broader educational and socio-cultural values. The development of educational software, which has been spearheaded in most countries by commercial interests, has resulted in much material produced being of dubious pedagogical
quality. Much of the multimedia software presently produced targets home computer users and is more appropriately classified as "edutainment" rather than being “truly educational.” Often, the poor quality software and hardware are pushed to developing countries as technology transfer package.

Ideally, industry should work along with education professionals in developing materials which are innovative but curriculum-related, and which meet clearly defined criteria for classroom use.

**Academic and Research Institutions**

There are a number of recent initiatives involving collaboration between universities and other research and development institutions, schools and the wider community. Successful projects may be financed by industry or state funds with technical know-how provided by the academic institutions. Universities have valuable contributions to make to curriculum development, teacher training or the development of appropriate educational software. They are usually better equipped than schools in terms of the necessary infrastructure and equipment, and may be able to link up with schools, libraries and other public sector institutions for sharing resources.

**International Initiatives**

Walker (1989) includes international co-operation as a vital component of policies for developing the use of informatics in education. International initiatives may result from the policies of international organizations such as
UNESCO, EU, World Bank, ASEAN Bank, etc., or they may be the outcome of bilateral arrangements between countries, whether North-North, North-South or South-South.

In developing countries, aid agencies, whether non-governmental or intergovernmental organizations, have influenced policy on the use of ICTs in education. International organizations such as UNESCO and the International Telecommunications Union (ITU) play a role both in formulating policies and in developing initiatives for incorporating ICTs into schools and communities. International funding agencies such as the World Bank and the United Nations Development Program (UNDP) are major actors in the development of projects. While intergovernmental organizations can play a valuable role in assisting countries in formulating appropriate policies, donor agencies may persuade governments to develop projects which they cannot sustain or expand, and cause educationally and culturally inappropriate software to enter the system. Sub-regional indigenous initiatives may be a partial answer to effective collaboration.

Technology Transfer through the Lens

In 1997, World Bank initiated World Links to find capacity-building strategies to prepare the youth of developing countries to compete in a world increasingly driven by information, knowledge and technology, thereby increasing access, bridging the digital divide, and improving the quality of education (worldbank.org, July 3, 2002). Learning from past mistakes of
“providing expensive equipment but with little or no support for teachers’ professional development, World Links introduces national ICT-in-education policies and community involvement, and includes other components, like wiring schools to the Internet, teacher training, assessment, sustainability, etc. Some innovative lessons that may equally be useful in industrialized countries are described below:

• Creative and Innovative Approach. Computer laboratories in developing countries take time and money, but they are made to work. Sometimes, student-teacher ratio is 80:1 and there are 10 to 20 computers in a school, and connecting the school to the Internet may be a dream. (In 1999, in Mauritius, I taught a class of 165 teachers on 13 computers). But the teachers are resourceful to split the class into groups that work on-line and off-line and to use technical solutions: store-and-forward emails, putting Web pages through emails, caching Web pages locally, and extensive uses of CD-ROMs (worldbank.org, July 3, 2002).

• Technical Support. Getting computers into schools is relatively easy but keeping them working is a greater challenge owing to electrical spikes, viruses, dust, heat, humidity and normal wear-and-tear. Most schools lack the funds for a full-time computer technician who often times is poached by other businesses. Sometimes students or technical staffs in schools and administration offices or prisoners (free labor) are trained to repair, refurbish and maintain the park of computers. They even outsource their technical support to private organizations. This is good
for career development, generating cash for supplies, and leadership technology.

- Telecommunications. Often telecommunications are government cash cow monopoly, old structures and limited to urban areas. The rates are flat and high. Non-competitive telecommunications infrastructure, policies, and regulations impede connectivity and sustainability. There is a strong need to liberalize the telecommunications sector to attract private and international partnerships for investment and modernization. Major international players in this promising sector have made strategic alliances in Africa and other developing countries.

  Fixed line dial-up connectivity is not a viable solution for vast and distant areas from the cities. In Uganda, some schools are connected to wireless broadband Internet (World Links and Gates Foundation’s initiatives). Wireless technologies are promising in reaching out to suburban and rural communities.

  As in Chile, The Ministry of Education can partner with the telecommunications business to provide schools with Internet connectivity, broadband services, Web hosting, email accounts, and technical assistance, all free of charge or at subsidized and affordable rates, in return for a wider customer-base of parents through students, tax exemptions and social capital. When schools or Ministries of education invest in high speed Internet access, there is an increase in satisfaction,
use, and integration of ICT into the curriculum (e.g., in Mauritania (worldbank.org, July 3, 2002)).

- Community. Often schools cannot afford recurrent costs (assuming some initiatives invested or donated the capital costs) that can be spread across a larger body of users. By sharing the facilities of the Internet-connected schools for adult and lifelong education, the schools can meet part of the costs and eventually the full costs - US$400 per month per school (worldbank.org, July 3, 2002). Thus some poor countries, like Uganda with a per capita income of US$310, can have sustainable networked schools by involving the community and bridging the digital divide between urban and rural areas, between in-school and out-of-school youth and between girls’ and boys’ access to education (70 percent of users at the community technology centers are women in Zimbabwe (Bloome, 2000)). What is needed is the seeding effort in capital investment, trained teachers and school personnel.

- Private Sector, Public Sector and Civil Societies’ Partnership. Equipping schools with ICT is a formidable task. Governments should seek strategic partnership with the private sector, which can equip schools, and provide cost-effective Internet connectivity and training or technical support in return for using the facilities after school hours for its profitable business. This can create some externalities like bringing electricity and telecommunications to the region, creating jobs, setup strong linkages with the community. For example, the State of
Karnataka, in India, partnered for five years with computer training company NIIT, which hired 1400 local trainers and, with the local communities, equipped seven hundred schools with computer laboratories in forty-five days.

- Broad Education Reforms. Equipping schools with ICT are expensive but the easiest part. Many countries focus on basic computer literacy skills only and have no clear strategies of integrating computers and the Internet into the curriculum for increasing learning. The curriculum is very examination oriented, rigid and overloaded, leaving little time for innovative classroom practices. According to SRI-World Links, enthusiastic teachers engage in collaborative projects and constructivist pedagogy but school administrators offer little support and incentives. School administrators should be trained in ICT, community activism and advocacy, and fund raising. Ministries of education must align curricula, exams and incentives with desirable educational outcomes.

- Training. Teachers’ education and training are central to a successful technology program. Teachers should receive formal training, and sustained and ongoing support from their colleagues to help them learn how best to integrate technology into their teaching. Training should help teachers be comfortable with using the technology and seeing beyond the technology to pedagogical and educational gains through student-centered collaborative learning environments within the classroom and the virtual classes of the world. It should transform
teachers from information consumers to producers, adapting the information for their own cultural and educational reality (worldbank.org, July 3, 2002). They can enhance their curriculum by tapping into online resources, exchange ideas and good practices, and get peer reviews with other teachers.

- Gender. Female education is critical in promoting social and economic development. Women are the primary care givers. But, in many developing countries, fewer girls attend secondary schools. Either in schools or community centers, girls can be empowered by ICT, which provides extended learning opportunities about health, education, business and teen-related information that may be taboo in certain societies. World Links stated that seventy percent of women in Mauritania claimed that the Internet brings freedom to them as women since they no longer need to depend on the controlled information given by their society and family (worldbank.org, July 3, 2002).

    Apart from gender, the digital divide impact both rural and urban out-of-school youth, workers, senior citizens, and physically and mentally challenged people. They can benefit from ICT through the schools, community centers or Internet Cafes (which are very popular in Africa).

- Intellectual Property Rights. To attract investment, business and international donors, developing countries should reinforce their
framework for protecting intellectual property rights against software piracy, copyrights on books and documents, etc.

- Leadership. Leaders need to have the vision for the youth of tomorrow. The latter drive the development engine. They must provide the strategic imperative to attract investment to finance ICT in education, engage public and private sectors, and civil societies to participate, streamline laws, practices and organizations, transform schools, and synergize the development dynamic. The political and socio-economic factors are responsible for the limited impact of ICT in some countries. Some authorities, teachers and school management have resisted the implementation of ICTs in schools because of a lost of control, and linguistic and cultural inappropriateness of most educational software available for many countries due to conflict with the traditional ways of transmitting and receiving information. This is a major issue with fundamental Muslim societies. Even Singapore edits the educational contents from the Internet. As in any revolution, the turbulence calls for more education, training and adaptability. The huge gap in the exploitation of technologies in education is mainly socio-economic and pedagogical but fundamentally political. What is required is a strong leadership to lead the revolution. Probably, this is what the poor countries need most! Africa has a lot of natural resources but with Western participation lack the political will to develop the countries on democratic principles.
Strategies

Briefly, there are some main problems that need attention immediately: schools, power (electricity), ICT infrastructure, educational materials, and teachers and training. When conventional methods have failed, I am willing to try some drastic ones. I am appealing to the hearts and minds of people who are better off to give a chance to get the people in poor developing countries on their feet ready for development. This appeal is especially for International agencies and private donors. This is a unique opportunity to do so with ICT as an enabler. Some strategies are:

To form and empower through training grass-root organizations; to mobilize them to rally support from the community, raise funds and, when it is possible, bring materials to build schools. Community ties are strong in rural regions. When they are fired up, they become the active agents of change.

1. To develop some form of energy from wood, fossil fuel, oil, wind or the sun (the latter two are still expensive). Some industrialized countries could build nuclear power plants in exchange for certain natural resources. Some students will pedal their cycle to generate enough electricity to recharge the batteries of their notebooks and personal digital assistants (PDAs).

2. To build the ICT infrastructure. A low-end multimedia system, preferably portable, can be built from cheap stocks. Again, college students can be trained to do a good job in their own countries. There are also cheap refurbished computers from eBay (an online auction company) or donated old computers that can be recycled and shipped by some non-profit organizations. Some older
generations of software that are no longer marketable in developed or newly
developed countries can be donated and still be used in the poor countries. Some
college students can go to these schools and trained them how to recycle and
maintain these computers. They can involve some local people in the
installation, too. Thus, the project will become sustainable. Also the local
government should negotiate with collaborating partners a preferential
telecommunications rate for satellite transmission.

3. To transmit educational material. Most educational materials exist in the
industrialized and newly industrialized countries. Many teachers will share their
lesson plans and notes in return for collaboration in some other areas of social
study, geography, etc. With the cooperation of the telecommunications
companies, anything in electronic form could be transmitted via satellites at
marginal cost. The local people should be involved in translating and adapt the
educational materials.

4. To train teachers on a massive scale. To give a crash course in pedagogy and an
orientation to college students or student teachers from industrialized, newly
industrialized and some developing countries, and bring them, under the
supervision of experienced teachers to train teachers in developing countries
while students earn credits during the summer vacation. The follow up can be
done online. This is a win-win situation for global knowledge transfer.
Future

Traditional solutions have not worked to-date to eliminate illiteracy in the world. What was lacking amongst other things was a catalyst of change and a delivery system that spans the world. ICT is just the right tool. It delivers online contents, which most already exist in advanced and new economies but need adaptation, and training for teachers and technicians. What is needed is the infrastructure, which is costly and the developing countries cannot afford. Where there is power and telecommunications, a viable popular solution is the cyber cafés. Just as the single line telephone used to attract a whole town to use it, in the same way, cyber cafés attract students, professionals and business people.

However, the future is promising. According to Bill Gates in the *Road Ahead*, there are plans to put into low orbit some four hundred satellites, which will completely span the world. Some low-cost studio broadcast via satellites that have been used in India and China will improve accessibility to ICT technology. Extending the digital contents from existing ICT infrastructure is possible at low marginal costs – a powerful multiplier effect. Research in solar and wind power, which are still expensive, will provide viable solutions to the lack of power on the ground. Smaller computers like notebooks and personal digital assistants (PDAs) will become studier and practical for harsher climates. We need to explore and develop more indigenous technology, like batteries from coconut milk, recharging batteries while riding bicycles or pedaling/bellowing at home, etc.
Finally, the old debate about choosing between ICT and other imperatives has shifted from one of trade-offs to one of complementarities. Numerous factors influence the extent and speed of social and economic development – not the least political stability, physical infrastructure, basic literacy, etc. The integration of ICT into the overall national development strategies can help facilitate implementation, expand the scope and coverage and increase the results of most of these factors.

In return for a safe world and a wider base for trade and commerce, ICT developed countries will extend the digital dividend at negligible marginal cost to help bridge the digital divide in the developing countries.

Closing

The conceptual model has been stretched to cover the poor developing countries. Some drastic approaches have been suggested above: creative and innovative approaches, technical support, community, private and public sector partnerships, broad education reforms, training, gender, intellectual property rights and leadership.

The solution lies mainly in good leadership and politics, matters of the heart and mind – the West be willing to let go of their digital dividends, help build the new infrastructure, transfer their accumulated educational materials online at negligible marginal cost, and support teacher training through volunteer, teachers and college students, local and abroad.

Language and culture are handicaps that the non-English speaking world has to live with until ICT matures up and delivers automatic translation.
At the beginning, technology can be used in teaching at the periphery that requires less computer systems, and later move towards the center of learning experiences.

Implications

ICT in education is a new discipline that keeps changing fast, leaving many people confused or ignorant of the potential solutions to some of the major problems of education today. This study charts a clear pathway through the territory and presents a qualitative and quantitative framework that can be used as a lens to examine the readiness and needs of a country in terms of ICT and lays the foundation for strategic technology planning for education. Basically, there are six components: Leadership and funding, participation of private sector and international strategic partnership, infrastructure, contents and curriculum, and teacher education and training, organization. A detailed framework is listed, as part of the answer to question 2 above. A given country has to collect appropriate data under the section Data and Metrics, analyze them under the various components of the model, and synthesize the results to obtain a deep and rich output, which, optionally with the traditional SWOT analysis, forms the basis of a strategic ICT plan for education.

The study examines the practices, mainly prevalent in three countries, Singapore, England and the United States, and proposes to Mauritius the best practices in terms of goals and strategies to realize the goals. The work is valid and applicable for many other countries. Finally, many developing countries will find inspiration to introduce ICT in education.
There are other implications for the current theme of school reforms, the integrative conceptual model for ICT education and development, the strategic plan for ICT education in Mauritius and the impact.

**Technology and School Reform**

Information and Computer Technology has been the driving force behind globalization, which has created new opportunities and challenges. Often times, technology changes faster than the school environment. There is an explosive increase in the number and type of technology resources available and a dramatic decrease in the total cost of ownership. Already, wireless mobile computing, palmtops (personal digital assistants), cellular phones have increased communications many folds. Ubiquitous computing is becoming a reality in some economically and technologically advanced countries.

Yet educators must keep pace with technological advances. This ability is challenging our education system and the school as an institution. As the school drifts away from the real world, mounting pressures from inside and outside school are increasing for the school to restructure itself to deliver relevant, effective and quality education. The technology to do so is here. What is needed is the goodwill, other resources, and above all, properly trained teachers, school leaders and administrative personnel, and more research.
Conceptual Model

A conceptual framework has been developed and tested in the case of Mauritius. The framework consists of a set of components (see answer to question 2) and embodies a set of tools (see p. 137 - 139, Chapter 5) to analyze the country’s readiness and needs for ICT education. It provides a lens to examine a country’s needs in terms of actual data to be collected, analyzed and synthesized. It forms the basis for conceptualizing a strategic technology education plan.

Strategic ICT Education Plan

The strategic plan evolved out of needs requirement from bottom-up and top-to-bottom approach. It sought consensus and ownership. It brings on strategic partnership and compact. The results are contributions to good ICT education planning, and can impact positively a full-blown scale of strategic ICT education planning in real life.

This plan will help Mauritius, or other countries, to undertake a more comprehensive approach in planning for ICT education, streamline resources, avoid wastage, provide coherent and effective goals and strategies, and sustain any initiative, project or program in ICT education. The author had strongly felt the lack of such a document in his practice. For fifteen years, ICT in secondary schools have progressed but at a slow rate and offered limited access and stark digital divide. It encountered many obstacles, ignorance, technological and humankind inadequacies. There were many wild propositions from opportunists who have moved elsewhere when the evaluation was done. The author struggled to introduce ICT in teacher training curricula
and extend it to primary pre-service teachers. So this plan will be a lighthouse to channel efforts for ICT education in uncharted territories.

I am glad to learn that ICT education will start in all primary schools with universal access as from 2003 through a loan from World Bank. Training in IT has started on a large scale with private and public sector partnerships. The construction of the Cyber City at Ebène will start soon. India, Singapore and Malaysia have partnered with Mauritius to develop the IT industry.

Impact

Most industrialized and some newly industrialized (NICs), like South East Asia, Latin America and South Africa, and some developing countries, including some small states economies (SIDs), have embarked on ICT education thus impacting pedagogical, technical, economic or social factors. South East Asia is benefitting immensely from ICT. For example, an open university has an enrollment of 100,000 students, and satellite technology beams down to many islands in the region.

The least developed countries of Africa, Latin America and Asia are severely handicapped by the need for more basic teaching and learning resources. However, it might cost less financially, in resources and time-wise, to invest into the technology that allows coverage, reuse, effectiveness, etc., in order to catch up with time. How to start mobilizing the resources? It is a matter of the heart and mind. (See section on technology transfer above). The impact of ICTs on the formal and informal education has profound implications for the traditional role of teachers, the status of students, and substantial changes in terms of the modalities of control and distribution of authorities
in the school system. As in any revolution, the turbulence calls for more education, training and adaptability. The huge gap in the exploitation of technologies in education is mainly pedagogical but fundamentally political.

The political and socio-economic factors are responsible for the limited impact of ICT in some countries. There are four main rationales for introducing computers in schools, namely, social, vocational, pedagogic and catalytic (Hawkridge, 1990). Most countries have started from the "restricted policy" based on the social and vocational rationales to the comprehensive policy of based on the pedagogical rationale, while paying lip service to the catalytic one (Duguet, 1989; Hawkridge, 1990). Some authorities, teachers and school management have resisted the implementation of ICTs in schools because of a lost of control, and linguistic and cultural inappropriateness of most educational software available for many countries due to conflict with the traditional ways of transmitting and receiving information.

Finally, the strategic plan for Mauritius has the potential to impact the following:

1. E-school and e-learning offer flexibility and convenience to further professional training, provide basic adult education, offer lifelong learning and curriculum support. This has can undercut the private tuition industry.

2. ICT will jumpstart the administration, provide good governance through e-government. Fast communications, like Email requires quick response, fast turnovers (unlike my request for study leave which took six months and some attachments got lost or eaten by rats). Parents can catch up with any missed
lessons of their children and their performance by weeks from the school website.

3. ICT will bring more accountability in the system. Transparency, communications and community involvement will impact the school.

4. ICT will connect the island to the rest of the world. Information and knowledge will be at a click away. This will further up more research and bring more innovations.

5. ICT will bring more accountability in the system. Transparency, communications and community involvement will impact the school.

Experience (What I Have Learnt)

This study deals with a broad subject of ICT in education in the context of the Information Revolution. Although I have focused mainly on three country case studies, namely Singapore, United Kingdom and United States, the scope of the study has invariably centrifuged notable experiences of other countries to enrich the essential knowledge to comprehend and develop a framework that can be used as a lens to analyze a country’s readiness and needs to adopt or enhance ICT education. It was a learning and satisfying experience to study a moving target that impacts widely and profoundly our lives. The Internet enabled a virtual tour of educational technology in action and I have become savvy with a lot of educational websites. Also I have learnt about handling complexity. I am happy to make a little contribution to the general theory and in particular to a national strategic plan for ICT education.
In the process, I dealt with data on a wide scale at different points in time. Often inaccuracies led me to corroborate the figures from different sources for the same time period. When figures are not available for the same time period, the best approach is to take data from the closest available period and consider the general state or trend rather than the absolute values. As for the metrics, the data were scattered and sometimes incomplete or unavailable, as they had never been related in this context.

The Internet provided a rich foray of secondary data, which I have used unreservedly. The primary data that I needed for the Mauritius case study were less than I originally planned for. They became available officially with the new and recent interest of the Government to embark on ICT education and development. However, my survey also covered areas and topics that the state surveys did not. Few parents are knowledgeable about ICT education and most of the survey forms were either blank or their ward(s) have filled them in. State schools are more or less homogeneous in terms of computer systems, connectivity, curriculum and teaching. There is a greater variability within the private secondary schools. The confessional schools and some star private schools have deployed ICT in education. The majority of the private schools have not taken full advantage of the matching grant from the Private Secondary Schools Authority yet they charge students for use. A minority of private schools has not introduced ICT in the school curriculum because the returns are less on investing on computers and Internet connectivity than on building classrooms to accommodate more students. In short, I learned to use what data or information became available and modify my appetite for gathering original data as planned, thus lessen the load of the investigation – work smart!
Recommendations

In the light of the study, some success factors to strategic technology education planning are: strong leadership imperative, together with public and private local (civil societies) and international partnership, is needed for sustainable funding, investment, and streamlining procedures and laws. The school is virtually extended to parents, community and business in an exchange of resources and participation. With business getting involved with the ICT education program in terms of curriculum relevance, software development, training and other resources, care is needed to check for commercially biased quality of software (edutainment) and for over-influencing the nature of education. However, business can enforce standards and accountability.

Government should minimize the digital divide by providing universal and quality access to all. The poor from the rural region, and inner cities and the out-of-school youth and seniors should be integrated into the system by proving access in the community. Industry should produce more affordable systems. The state should encourage girls and women to study and practice ICT as professionals.

The job market is an important catalyst for ICT education. Students are attracted to the subject because of the good prospects of employment. Parents want a good future for their kids; businesses expect quality manpower for their investment; and politicians love to see participation, employment and satisfaction. This virtuous circle is incomplete without well-trained teachers who are the vectors of change. They have to be trained, equipped well through discounted or free use of computers or notebooks connected to the Internet; retrained continually through distance education and/or workshops; and rewarded for good performance. Proper training must make them
comfortable with the ICT curriculum. Specialist technical and curriculum support are needed for both teaching ICT as a subject and integrating ICT across the curriculum. Also, the administrative personnel, management and supervision staff must be properly trained in the use of ICT for efficient and effective governance.

The use of ICTs must be seen in the context of educational objectives (Bloom, Englehart, Furst, Hill, & Krathwohl [Eds.], 1956), educational environment, target groups and the financial means available. Therefore, of resources has to be adjusted between competing sources, such as infrastructures, training, content and human resource. Education must always be the driving force behind these technological innovations (COM, 2001).

There is need for ownership of the project or program. A bottom-up as well as a top-down approach is needed. The local participation in terms of producing contents and adapting foreign software is a safeguard against deculturization.

Proper planning is important. While it is difficult to plan for long term ICT education, it is worthwhile to plan for a medium term with frequent periodic updates. There is need for further research into effective means of incorporating these technologies into the curriculum and into assessment.

The framework for ICT education is a useful contribution to a strategic plan. The insight gained and the findings could be used to work on a real full-scale plan.

Finally, the most important but elusive issue is sustainability. There are evidence of major mistakes by donor organizations or countries of unsustainable projects. Pushing in equipment often without or inappropriate software into schools is a blunder. Eventually, the donors have realized this thorny issue. In fact, sustainability includes (1)
teacher training that make them comfortable to teach with and even maintain ICT, (2) infrastructure with computer systems, which are networked and connected to the Internet to realize the full beneficial effects, and appropriate educational software, (3) continuous funding, (4) participation of the parents and the community (civil society) in sharing resources and training, (5) public and private investments, (6) international involvement for enrichment, renewal, technology transfer and exchange, and local participation for development and adaptation of software and best practices to local culture, (7) training of all administrative staff and participation in efficient and effective schools and e-governance, (8) job market in ICT applications and industry, and (9) higher education and training.

Future Directions

The present study raises some interesting issues that any future research could focus on in order to better understand the scope of this work.

- Metrics: Observe the evolution of infrastructural, organizational and pedagogical indicators and their values to determine the threshold input values or range of values that maximize payoffs.
- ICT in education: To situate ICT use in education on the spectrum from the center to the periphery of educational experience according to socio-economic status of countries implementing ICT in education. This will shed light on the loading of ICT (too much or too little of technology) in teaching according to socio-economic development.
• Internet educational content management: To organize effectively the contents for learning in formal, non-formal and lifelong education for teacher training, students, the community and industry. There are a lot of undesirable and illicit materials on the Internet that are pushed down on children or can be downloaded by some students, How to filter or block these harmful contents is a challenge.

• Pedagogy and learning: This is a vast area of research involving the learner, the facilitator and the computer to maximize learning, which is the core of educational experience (see diagram on page 168). We need more research and emphasis in instructional design, teacher training and e-learning. The need to innovate and be creative is the essence of future educational policy, which is under pressure from government and business to be competitive.

• Strategic planning: It is about strategic technology planning of the ephemeral. More research could be done about effective strategic planning of ICT and education in a highly turbulent period to deploy resources effectively and minimize technology obsolescence.

• ICT transfer model to developing countries: To negotiate a new global social order, as García Ferrer, the vice-president of the community for cooperation and development of the Madrid (Spain) Federation of Municipalities and Provinces put it (Drago, 2001) for digital dividends to address the digital divide.

**Conclusion**

In our search for wealth creation in a knowledge society that is made possible by the computer and information technologies, and hence its implication in education, we
have to steer ourselves to meaningful people-centered technologies that enhance lifestyle. It is also imperative to seek a new social order where the digital capital of the advanced countries and the newly industrialized countries could extend the digital dividends to minimize the digital divide within and between countries, especially the developing countries. ICT. As any technology is not neutral in the development process, care needs to be exercised in the technology transfer with respect to culture, religion and societies. Strategic alliances from industry, international cooperation from organizations, like UNESCO, World Bank, etc., non-governmental organizations and the civil societies could contribute to alleviate poverty, make life more comfortable and the world peaceful and fair through ICTs and education where the extension of facilities is at low marginal cost when the initial infrastructure is in place. Adopting ICTs and its consequent education and training in developing countries is no longer a matter of choice but survival.

New technologies, like semantic web that searches by meaning instead of key words, talking web using speech recognition and language translators, pervasive computing with affordable, wireless, portable and wearable devices, will bring people to communicate more and hopefully to better understand human nature through a global consciousness. The school as we know it will change drastically with flexible learning, blurring the line learning and play, between home and school activities, and involving parents, community and business. The digital child will learn to create and innovate for a living.

However, some reflections at this crossroad are important. Who is behind the technology push in our schools? Maybe teachers but most probably it is industry! So, it
has been with radio and television! Admittedly, there is some goodness in all but they are just powerful tools and no panacea for all education problems, as some advocates would make us to believe. However, ICT in education will provide new skills for the networked world to increase productivity and creativity, and hopefully.

To use or not to use technology in education is not about technology, it about children. The future is embodied in the education that prepares our children to live in a better world. So, just as Shakespeare in Twelfth Night, says, “if music be the food of love, play on” (Shakespeare, 2001), in the same way, I say, “if ICT education be the fuel to learning, carry on.”

The next big application of computers will be in education!
APPENDIX A

INTERNET USERS, GNP PER CAPITA
APPENDIX B

THE INDEX OF TECHNOLOGICAL PROGRESS
## The Index of Technological Progress

<table>
<thead>
<tr>
<th>Country</th>
<th>Fax Machines</th>
<th>Mobile Phones</th>
<th>Internet* Hosts</th>
<th>Personal Computers</th>
<th>TVs</th>
<th>ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>580.28</td>
<td>1365.66</td>
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<td>U.K.</td>
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**Other OECDs**

<table>
<thead>
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<th>Country</th>
<th>Fax Machines</th>
<th>Mobile Phones</th>
<th>Internet* Hosts</th>
<th>Personal Computers</th>
<th>TVs</th>
<th>ITP</th>
</tr>
</thead>
<tbody>
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<td>Norway</td>
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<td>306.63</td>
<td>2726.62</td>
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<td>Japan</td>
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<td>1500.68</td>
<td>45.58</td>
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<td>6745.53</td>
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<td>Australia</td>
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<td>198.24</td>
<td>2851.78</td>
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<td>Canada</td>
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**Other NICs**

<table>
<thead>
<tr>
<th>Country</th>
<th>Fax Machines</th>
<th>Mobile Phones</th>
<th>Internet* Hosts</th>
<th>Personal Computers</th>
<th>TVs</th>
<th>ITP</th>
</tr>
</thead>
<tbody>
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<td>Hong Kong</td>
<td>456.95</td>
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<td>53.02</td>
<td>1614.32</td>
<td>3765.99</td>
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<tr>
<td>Korea (Rep.)</td>
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<td>13.52</td>
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<td>3032.76</td>
<td>26.29</td>
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</table>

**Developing Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Fax Machines</th>
<th>Mobile Phones</th>
<th>Internet* Hosts</th>
<th>Personal Computers</th>
<th>TVs</th>
<th>ITP</th>
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</thead>
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<tr>
<td>Mauritius</td>
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<td>2.59</td>
<td>421.39</td>
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<td>Malaysia</td>
<td>42.78</td>
<td>526.24</td>
<td>7.35</td>
<td>373.58</td>
<td>1592.21</td>
<td>13.38</td>
</tr>
<tr>
<td>Russia</td>
<td>2.56</td>
<td>16.17</td>
<td>4.11</td>
<td>199.61</td>
<td>3862.99</td>
<td>12.05</td>
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<tr>
<td>Chile</td>
<td>16.80</td>
<td>211.09</td>
<td>7.61</td>
<td>382.99</td>
<td>2233.41</td>
<td>11.21</td>
</tr>
<tr>
<td>S. Africa</td>
<td>23.84</td>
<td>211.13</td>
<td>16.20</td>
<td>298.46</td>
<td>1230.04</td>
<td>8.75</td>
</tr>
<tr>
<td>China</td>
<td>5.76</td>
<td>58.15</td>
<td>0.09</td>
<td>35.70</td>
<td>2377.62</td>
<td>7.29</td>
</tr>
</tbody>
</table>

Source: Table 3. Rodriguez, Francisco, 2000: Are Poor Countries Losing the Information Revolution, Rodriguez, Francisco and Wilson. Ernest J., University of Maryland/ * per 10,000 people. Other measures refer to 1,000 people.

OECD's ICCP panel of statistical experts defined ICTs as the set of activities which facilitate by electronic means the processing, transmission and display of information. ICTs include personal computers, mobile phones, Internet hosts, fax machines, and television. The index of technological progress is an index of products and ranges from 0 – 100. It measures the capacity of different countries to process information useful to consumers and firms, that is, it does not take into account the hard and soft infrastructures necessary to provide them. It captures the main differences across countries in their capacity to process information by electronic means. While a single product is an ‘overworked’ measure to describe technological progress, a group of recent technologies do better. Other potential enablers like digital radio, television and media are not considered here because they are still new technologies that are not widely distributed.

APPENDIX C

POVERTY RATES IN SOME SMALL STATES
Poverty

There is some evidence that poverty levels tend to be higher, and income distribution more uneven, in smaller than in larger states. Where this is so, income volatility can create additional hardship as the poor are less able to weather negative shocks to their incomes. The graph below suggests that within the sample of small states for which data were available, those lying above the trend line have a higher level of poverty than might be expected, given their relative income levels.

Poverty Rates in Some Small States (proportion of population below the poverty line)

Source: World Bank database for 70 developing countries.
APPENDIX D

QUESTIONNAIRES
Questionnaire for Students

Please fill in the questionnaire and return it to your teacher. You do not have to write your name. You are free to express yourself.

1. Your school name? ________________________________

2. The school district ______________________________

3. Which form are in _? State stream Art _ Science _ Tech _ Commercial_

4. Have you studied computer courses at school?
      Y _ N _ Y _ N _ Y _ N _

   1. Why? _______________________________________
   2. Why? _______________________________________
   3. Why? _______________________________________

5. If YES to question 4.2, why have you been selected?
   ______________________________________________

6. Do you think that your computer laboratory is equipped properly? Y _ N _

   What do you need more? ____________________________

   ______________________________________________

7. Do you need more time working on the computers? Y _ N _.

8. Have you ever used the Internet?
   At school Y _ N _. At home Y _ N _. At a friend Y _ N _.
   Cyber café Y _ N _. Other Y _ N _.

9. What for?
   Look for information Y _ N _
   Send email Y _ N _
   Chat Y _ N _
   Do homework Y _ N _
   Play game(s) Y _ N _
   Other Y _ N _

10. Have you downloaded anything that you should not tell your parents or teacher? Y _ N _

11. Would you join a school computer club after school hours or Saturdays? Y _ N _

12. Would you like to pursue higher studies in computer science? Y _ N _

13. Which job would you like to do? ____________________________

   Thank you.
Information and Computer Technology Planning

Questionnaire for Teachers of secondary schools in Mauritius.

Please fill in this form. Do not write your name and feel free to express your self. Your input is important and will contribute to the development of the subject in schools. When you are done, please hand it in, together with all other questionnaires of the survey to the rector/principal/manager of your school.

1 State your school type? State ___ Confessional ___ Private ___.

2. Rural ___ or Urban ___ Students are boys only? __. Girls only __. Mixed ___.

3. School district ____________________________.

4. Total # teachers ____ Teachers of ICT only. ____ Teachers integrating ICT in curr. M _____. F _____. M _____. F _____. M _____. F _____.

5. How many students do you have in your class
   Form I II III IV V VIL VIU
   M_ F_ M_ F_ M_ F_ M_ F_ M_ F_ M_ F_ M_ F_

6. Tick highest computer qualification that you have? Or equivalent to?
   SC __ HSC __ Diploma __ Degree __ PGCE __ MSc __. Other ___.

7. If you are a general teacher, please rate your knowledge of computer literacy?
   No ___. Little ___. Average ___. Good ___. Excellent ___.

8. Do you use the Internet? Y__ N__.
   Mainly for what?
   Look for information Y__ N__ Do homework Y__ N__
   Send email Y__ N__ Play game(s) Y__ N__
   Chat Y__ N__ Other Y__ N__

9. Have you ever used the Internet?
   At school Y__ N__ At home Y__ N__ At a friend Y__ N__
   Cyber café Y__ N__ Other Y__ N__.

10. Do you need more time working on the computers? Y__ N__.

11. Do you think that your computer laboratory is equipped properly? Y__ N__
    What do you need more? ________________________________________
    __________________________________________________________________

276
13. Does your laboratory have Internet connection? Y __ N __.

14. Have you downloaded anything that you should not? Y __ N __

15. Have you received training in

<table>
<thead>
<tr>
<th>Training Area</th>
<th>MIE</th>
<th>Ministry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Literacy (hw, sw, appl.)</td>
<td>Y __ N __</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>ICT in Education Leadership</td>
<td>Y __ N __</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Technology in Administration</td>
<td>Y __ N __</td>
<td>Y __ N __</td>
</tr>
</tbody>
</table>

16. Do you need training?

<table>
<thead>
<tr>
<th>Area</th>
<th>Y __ N __</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Literacy</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Computer Studies</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Computing/Computer Science</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Integrating ICT into the curriculum?</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Which subject?</td>
<td></td>
</tr>
<tr>
<td>Maths.</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Science</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Technology</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Languages</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Social sciences</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Arts</td>
<td>Y __ N __</td>
</tr>
<tr>
<td>Other (specify!)</td>
<td>Y __ N __</td>
</tr>
</tbody>
</table>

17. If you feel that you can integrate ICT in another subjects, i.e., use ICT to teach teach some subject(s) (which ones _________________________)?

How comfortable do you feel to do this?

No __. Little __. Average __. Good __. Excellent __.

18. What do you think has been the main problems in your school to teach

<table>
<thead>
<tr>
<th>Subject</th>
<th>_________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Literacy</td>
<td>_________________________</td>
</tr>
<tr>
<td>Computer Studies</td>
<td>_________________________</td>
</tr>
<tr>
<td>Computing/Computer Science</td>
<td>_________________________</td>
</tr>
</tbody>
</table>

Integrating ICT into the curriculum?

| Which subject?                   | _________________________ |
| Maths                            | _________________________ |
| Science                          | _________________________ |
| Technology                       | _________________________ |
| Languages                        | _________________________ |
| Social sciences                  | _________________________ |
| Arts                             | _________________________ |
| Other (specify!)                 | _________________________ |
19. How would you describe your style of teaching? If a mixture, state approximate percentage?
   Lecture
   Individual student’s participation
   Team work (collaborative learning)
   Project work. Individual __________. Group __________
   Research __________

20. What have been the difficulties that you have met in teaching ICT at your schools?

21. What do you think could be done to solve these problems?

22. Which software do you use?

23. Can you use any multimedia authoring? Y __ N __

24. Can you do any web design? Y __ N __.

25. Have you downloaded any lesson plans from the Internet? Y __ N __.

26. Have downloaded any teaching materials from the Internet? Y __ N __.

27. Would you make any useful suggestion how we can enhance ICT in Education?

28. For ICT in education in your school for the year 2003 - 2010, state briefly your Vision

   Mission

   Goals
29. Have you ever raised funds to finance the computer laboratory? Y ___ N ___.
   If YES, how much did you get last year? MRS. ________.
   If NO, why? ________________________________

30. If you have problems: hardware, software or integrating technology into teaching, whom do you refer to? ________________________________

31. Are you interested in promoting a computer club at your school? Y - N ___.

32. Please fill in the types of computers in the computer laboratory.

Number of Workstations in Each Category

<table>
<thead>
<tr>
<th>Computer Platform (including laptops)</th>
<th>FY 02-Type A</th>
<th>FY02-Type B</th>
<th>FY02-Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function:</td>
<td>Function:</td>
<td>Function:</td>
<td></td>
</tr>
<tr>
<td>Multimedia computers with CD-ROM and Internet capability using browser; capable of running high-end applications &amp; streamed video</td>
<td>Multimedia computers with CD-ROM and Internet capability using browser</td>
<td>Computers with or without Internet capability</td>
<td></td>
</tr>
<tr>
<td>Memory: 128 MB RAM or higher</td>
<td>Memory: 32 MB RAM or higher</td>
<td>Memory: Less than 32 MB RAM</td>
<td></td>
</tr>
<tr>
<td>Processor: 500 MHz or higher</td>
<td>Processor: 225 MHz or higher</td>
<td>Processor: Less than 225 MHz</td>
<td></td>
</tr>
<tr>
<td>Windows/PC computers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple/Macintosh computers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin Client Systems operating from a server (classify according to function only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>279</td>
</tr>
</tbody>
</table>
Information and Computer Technology Planning

Questionnaire for Rectors/Principals/Managers of secondary schools in Mauritius.

Please fill in this form. Do not write your name and feel free to express your self. Your input is important and will contribute to the development of the subject in schools. When you are done, please hand it in, together with all other questionnaires of the survey to the investigator.

1. State your school type? State ___ Confessional ___ Private ___.

2. Rural ___ or Urban ___. Students are boys only? __. Girls only __. Mixed ___.

3. School district ____________________________.

4. Total no. of pupils ______. teachers ______. Teachers teaching ICT. ______.

   M _____ F _____  M _____ F ____.  M _____ F _____

5. How many computers are there in the Administrative office __. Library __. Computer Lab. ___ Elsewhere ___?

6. Please rate your knowledge of computer literacy?

   No __. Little __. Average __. Good ___. Excellent ___.

7. Have you received training in

   Computer Literacy (hw, sw, appl.)  MIE Ministry
   Y ___ N ___  Y ___ N ___
   ICT in Education Leadership  Y ___ N ___  Y ___ N ___
   Technology in Administration.  Y ___ N ___  Y ___ N ___

8. For ICT in education in your school for the year 2003 - 2010, state briefly your Vision

   ____________________________________________________________

   Mission
   ____________________________________________________________

   Goals
   ____________________________________________________________

9. Have you ever raised funds to finance the computer laboratory? Y ___ N ___.

   If YES, how much did you get last year? MRS. ____________.

   If NO, why? ____________________________________________

10. Please tell us what could or should be done to promote ICT education in schools?

    Write on the other side of the page. Thank you.
Information and Computer Technology Planning

Questionnaire for Rectors/Principals/Managers of secondary schools in Mauritius.

Please fill in this form. Do not write your name and feel free to express your self. Your input is important and will contribute to the development of the subject in schools. When you are done, please hand it in, together with all other questionnaires of the survey to the investigator.

1. State your school type? State ___ Confessional ___ Private ___.

2. Rural ___ or Urban ___ Students are boys only? __. Girls only __. Mixed ___.

3. School district ________________________________________________________.

4. Total no. of pupils _______. teachers _______. Teachers teaching ICT. _______
   M _____. F _____. M _____. F _____. M _____. F _____.

5. How many computers are there in the
   Administrative office __. Library __. Computer Lab. __ Elsewhere ___ ?

6. Please rate your knowledge of computer literacy?
   No __. Little __. Average __. Good __. Excellent ___.

7. Have you received training in
   Computer Literacy (hw, sw, appl.) Y ___ N ___ Y ___ N ___
   ICT in Education Leadership Y ___ N ___ Y ___ N ___
   Technology in Administration Y ___ N ___ Y ___ N ___

8. For ICT in education in your school for the year 2003 - 2010, state briefly your
   Vision
   ___________________________________________________________________
   Mission
   ___________________________________________________________________
   Goals
   ___________________________________________________________________
   ___________________________________________________________________

9. Have you ever raised funds to finance the computer laboratory? Y ___ N ___.
   If YES, how much did you get last year? MRS. _____________.
   If NO, why? _______________________________________________________

10. Please tell us what could or should be done to promote ICT education in schools?
    Write on the other side of the page. Thank you.
Questionnaire for Parents
Please fill in the questionnaire and return it through your child/children to his/her teacher.

1. Does your child/children take computer classes at a secondary school? Y ___ N__.

2. If NO to question 1, would you like them to study any computer courses at school?
   Yes ____ or No ____.
   Why? ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

3. If YES to question 3, which class would you allow your child/children to do?
   Yes ____ or No____    Yes ____ or No____    Yes ____ or No____

4. A computer laboratory is costly to build and maintain and renew.
   Would be willing to contribute financially towards a computer laboratory?
   Yes ____ or No____.
   If YES, how much? __________________________________________________
   If NO, why? _________________________________________________________
   ________________________________________________________________

5. Do you have a computer at home?   Yes ____ or No____.

6. If YES to question 5, is it connected to the Internet? Yes ____ or No____.

7. If NO to question 5, do you intend to buy one
   with Internet
      Never  This year  Next year  Later
      Y ___ N__  Y ___ N__  Y ___ N__  Y ___ N__
   without Internet
      Y ___ N__  Y ___ N__  Y ___ N__  Y ___ N__
   If never, why? ________________________________________________________

8. What do you think about using computers to learn about other subjects?
   You can use the back of the page to give us your valuable input?
   Thank you.
Information and Computer Technology Planning
Inspectorate of secondary schools in Mauritius.

Focused free form Interview. Main questions.

1. State your Inspectorate? State ___ Private ___.

2. Have you received training in?
   - Computer Literacy (hw, sw, appl.) MIE Y _ N _ Ministry Y _ N _
   - ICT in Education Leadership Y _ N _ Y _ N _
   - Technology in Administration. Y _ N _ Y _ N _

3. Please rate your knowledge of computer literacy?
   - No __. Little __. Average __. Good __. Excellent __.

4. Do you have problems staffing rural ___ or urban ___ schools?

5. Do you think there is digital divide in our schools by
   - Rural ___ Urban ___ Male __. F __. Income group?
   - How can we bridge the gap?

6. What are the main problems of providing schools with computer systems?

7. What are the ICT short/medium/long term plans of the Ministry or private schools?

8. Please tell us what could or should be done to promote ICT education in schools?

9. For ICT in education in your school for the year 2003 - 2010, state briefly your

   Vision
   ___________________________________________________________________

   Mission
   ___________________________________________________________________

   Goals
   ___________________________________________________________________

   ___________________________________________________________________

   Thank you.

1. What is your background? ________________________________

2. Please rate your knowledge of computer literacy?
   No __. Little __. Average __. Good __. Excellent __.

3. How do you think we can improve schools through
   Computer Literacy (hw, sw, appl.)
   Integrating ICT in curriculum
   Using technology in Administration.
   Extending school through technology?

4. How can we sustain proper ICT education?

5. How can we be innovative an creative through ICT education?

6. For promoting ICT education in Mauritian schools, during 2003 – 07, What are our
   Vision
   Mission
   Goals?
   Strategies

7. How do we solve some of the problems that come up?

   Note: After the first round of interviews, the results are presented to the experts individually, and they are asked for comments. They are asked question 6 again on the second round. The process is repeated on the third round. Most answers are expected to be stable by then. After analyzing the non-agreed upon goals/strategies, they may be rejected or amended.
APPENDIX E

MULTIMEDIA NETWORKED CLASSROOM
Multimedia Networked Classroom
APPENDIX F

REPUBLIC OF MAURITIUS
Republic of Mauritius

A Map

Agalega Islands, Cargados Carajos Shoals, and Rodrigues are not shown.

0 2.5 5 km
0 2.5 5 mi

Indian Ocean

PORT LOUIS

Mauritius Introduction
APPENDIX G

INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) SURVEY
### Information and Communications Technology (ICT) Survey in maintained primary, secondary and special schools in England: 1998 - 2001 (provisional)

<table>
<thead>
<tr>
<th>Percentage of schools connected to the Internet</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
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<td>primary schools</td>
<td>17</td>
<td>62</td>
<td>86</td>
<td>96</td>
</tr>
<tr>
<td>secondary schools</td>
<td>83</td>
<td>93</td>
<td>98</td>
<td>&gt;99</td>
</tr>
<tr>
<td>special schools</td>
<td>31</td>
<td>60</td>
<td>92</td>
<td>97</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>28</td>
<td>66</td>
<td>88</td>
<td>98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average number of computers per school used mainly for teaching and learning</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary schools</td>
<td>13.3</td>
<td>16.1</td>
<td>17.8</td>
<td>20.7</td>
</tr>
<tr>
<td>secondary schools</td>
<td>100.9</td>
<td>101.3</td>
<td>112.6</td>
<td>127.7</td>
</tr>
<tr>
<td>special schools</td>
<td>18.5</td>
<td>21.0</td>
<td>21.3</td>
<td>24.3</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>27.1</td>
<td>29.5</td>
<td>32.6</td>
<td>37.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average number of pupils for each computer used mainly for teaching and learning</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary schools</td>
<td>17.6</td>
<td>13.4</td>
<td>12.6</td>
<td>11.8</td>
</tr>
<tr>
<td>secondary schools</td>
<td>8.7</td>
<td>8.4</td>
<td>7.9</td>
<td>7.1</td>
</tr>
<tr>
<td>special schools</td>
<td>4.5</td>
<td>3.7</td>
<td>3.7</td>
<td>3.2</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>13.8</td>
<td>11.2</td>
<td>10.5</td>
<td>9.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average number of computers per school used mainly for management and administration purposes</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>primary schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>secondary schools</td>
<td>-</td>
<td>2.2</td>
<td>2.3</td>
<td>2.6</td>
</tr>
<tr>
<td>special schools</td>
<td>-</td>
<td>13.1</td>
<td>15.5</td>
<td>18.4</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>-</td>
<td>3.7</td>
<td>3.8</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>4.0</td>
<td>4.4</td>
<td>5.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average expenditure on ICT per school (£) (2)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>primary schools</td>
<td>3,600</td>
<td>7,000</td>
<td>8,300</td>
<td>10,300</td>
</tr>
<tr>
<td>secondary schools</td>
<td>40,100</td>
<td>45,400</td>
<td>50,100</td>
<td>60,300</td>
</tr>
<tr>
<td>special schools</td>
<td>7,600</td>
<td>10,200</td>
<td>12,000</td>
<td>13,300</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>9,400</td>
<td>13,100</td>
<td>15,000</td>
<td>18,100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage of teachers who feel confident in the use of ICT</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>primary schools</td>
<td>64.7</td>
<td>67.8</td>
<td>67.1</td>
<td>76.4</td>
</tr>
<tr>
<td>secondary schools</td>
<td>60.8</td>
<td>66.1</td>
<td>65.3</td>
<td>70.2</td>
</tr>
<tr>
<td>special schools</td>
<td>62.8</td>
<td>67.6</td>
<td>73.4</td>
<td>76.7</td>
</tr>
<tr>
<td>all schools (1)</td>
<td>62.7</td>
<td>67.0</td>
<td>66.5</td>
<td>73.4</td>
</tr>
</tbody>
</table>

(1) An estimate for all maintained primary, secondary and special schools. Other types of school excluded.
(2) Includes reported expenditure on teaching and learning and management and administration.
APPENDIX H

MAIN SURVEY FINDINGS
### Primary / Secondary / Special Schools

<table>
<thead>
<tr>
<th></th>
<th>PRIMARY</th>
<th>SECONDARY</th>
<th>SPECIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average computers per school.</td>
<td>13</td>
<td>101</td>
<td>19</td>
</tr>
<tr>
<td>The average number of pupils per computer</td>
<td>18</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Total expenditure on ICT for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- teaching and learning:</td>
<td>£48.5 million</td>
<td>£118.6 million</td>
<td>£7.4 million</td>
</tr>
<tr>
<td>- administration:</td>
<td>£18.5 million</td>
<td>£24.2 million</td>
<td>£1.9 million</td>
</tr>
<tr>
<td>The average expenditure per school on ICT for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- teaching and learning:</td>
<td>£2,649</td>
<td>£33,259</td>
<td>£6,034</td>
</tr>
<tr>
<td>- administration:</td>
<td>£1,010</td>
<td>£5,798</td>
<td>£1,523</td>
</tr>
<tr>
<td>The average expenditure per pupil on ICT for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- teaching and learning:</td>
<td>£11</td>
<td>£38</td>
<td>£73</td>
</tr>
<tr>
<td>- administration:</td>
<td>£4</td>
<td>£8</td>
<td>£18</td>
</tr>
<tr>
<td>Number(or percentage) of schools which were connected to the Internet.</td>
<td>3,124(17%)</td>
<td>2,965(83%)</td>
<td>357(31%)</td>
</tr>
<tr>
<td>Percentage of schools with an ICT development plan.</td>
<td>53%</td>
<td>83%</td>
<td>65%</td>
</tr>
<tr>
<td>Percentage of teachers with a personal e-mail address.</td>
<td>1.7</td>
<td>8.8</td>
<td>2</td>
</tr>
<tr>
<td>Percentage of pupils with a personal e-mail address.</td>
<td>0.2</td>
<td>2.7</td>
<td>below 1%</td>
</tr>
<tr>
<td>Percentage of teaching staff who felt confident in the use of ICT within the curriculum.</td>
<td>65%</td>
<td>61% [see a below]</td>
<td>63%</td>
</tr>
<tr>
<td>Teaching staff who had received some training in the use of ICT.</td>
<td>90%</td>
<td>85%</td>
<td>89%</td>
</tr>
<tr>
<td>Teaching staff who had undertaken updated training in ICT in the last two years</td>
<td>45%</td>
<td>36%</td>
<td>46%</td>
</tr>
</tbody>
</table>

*a The percentage varied between 86 per cent in Business Studies Departments and 36 per cent in Physical Education Departments*
advanced.org (July 19, 2001). Think quest. URL http://www.advanced.org/thinkquest/


dbm.state.md.us. (September 6, 2001). IT policy: The Foundation for Policy. URL http://www.dbm.state.md.us/mdplan.


URL http://www.entovation.com/genderdivide/

http://www.exploratorium.edu/IFI/resources/constructivistlearning.html


grants/grants01/rfp/617.html


http://www.futureofchildren.org


