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ICT in education around the world: trends, problems and prospects

W.J. Pelgrum
N. Law

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Fundamentals of educational planning

The booklets in this series are written primarily for two types of clientele: those engaged in educational planning and administration, in developing as well as developed countries; and others, less specialized, such as senior government officials and policy-makers who seek a more general understanding of educational planning and of how it is related to overall national development. They are intended to be of use either for private study or in formal training programmes.

Since this series was launched in 1967 practices and concepts of educational planning have undergone substantial change. Many of the assumptions which underlay earlier attempts to rationalize the process of educational development have been criticized or abandoned. Even if rigid mandatory centralized planning has now clearly proven to be inappropriate, this does not mean that all forms of planning have been dispensed with. On the contrary, the need for collecting data, evaluating the efficiency of existing programmes, undertaking a wide range of studies, exploring the future and fostering broad debate on these bases to guide educational policy and decision-making has become even more acute than before. One cannot make sensible policy choices without assessing the present situation, specifying the goals to be reached, marshalling the means to attain them and monitoring what has been accomplished. Hence planning is also a way to organize learning: by mapping, targeting, acting and correcting.

The scope of educational planning has been broadened. In addition to the formal system of education, it is now applied to all other important educational efforts in non-formal settings. Attention to the growth and expansion of education systems is being complemented and sometimes even replaced by a growing concern for the quality of the entire educational process and for the control of its results. Finally, planners and administrators have become more and more aware of the importance of implementation strategies and of the role of different regulatory mechanisms in this respect: the choice of financing methods, the examination and certification procedures or various other regulation

and incentive structures. The concern of planners is twofold: to reach a better understanding of the validity of education in its own empirically observed specific dimensions and to help in defining appropriate strategies for change.

The purpose of these booklets includes monitoring the evolution and change in educational policies and their effect upon educational planning requirements; highlighting current issues of educational planning and analyzing them in the context of their historical and societal setting; and disseminating methodologies of planning which can be applied in the context of both the developed and the developing countries.

For policy-making and planning, vicarious experience is a potent source of learning: the problems others face, the objectives they seek, the routes they try, the results they arrive at and the unintended results they produce are worth analysis.

In order to help the Institute identify the real up-to-date issues in educational planning and policy-making in different parts of the world, an Editorial Board has been appointed, composed of two general editors and associate editors from different regions, all professionals of high repute in their own field. At the first meeting of this new Editorial Board in January 1990, its members identified key topics to be covered in the coming issues under the following headings:

1. Education and development.
2. Equity considerations.
3. Quality of education.
4. Structure, administration and management of education.
5. Curriculum.
6. Cost and financing of education.
7. Planning techniques and approaches.
8. Information systems, monitoring and evaluation.

Each heading is covered by one or two associate editors.

The series has been carefully planned but no attempt has been made to avoid differences or even contradictions in the views expressed by the authors. The Institute itself does not wish to impose any official

doctrine. Thus, while the views are the responsibility of the authors and may not always be shared by UNESCO or the IIEP, they warrant attention in the international forum of ideas. Indeed, one of the purposes of this series is to reflect a diversity of experience and opinions by giving different authors from a wide range of backgrounds and disciplines the opportunity of expressing their views on changing theories and practices in educational planning.

Since the early 1980s, societies have become increasingly concerned with the rapid progress of technology and the prospects it holds for the future in facilitating all aspects of life: work, leisure and education.

The integration of computers and technology into schools is an expensive and sometimes complex process. It requires all the necessary equipment, competent staff to get it up and running, technical support, and teaching of others to use it correctly and effectively. However, its advantages are evident, and the benefits that it can bring to schools and their pupils are significant enough to make the introduction of technology into the classroom one of the priorities of educational planners in both developed and developing countries, although the challenges and obstacles that may need to be overcome in both of these settings can be quite different.

As the title suggests, this booklet tackles the main problems and questions that arise when considering or implementing ICT integration. The authors have striven to find solutions and have made suggestions to planners and administrators in the process of introducing technology into schools or considering its introduction. They have also discussed some possible goals for ICT in schools, some of the achievements to date as well as some of the possible negative side effects for student learning. They have cited from previous research studies in order to present teachers' observations and school administrators' and teachers' expectations for the future.

The booklet clearly demonstrates for planners the potential of ICT in schools and the role it can play in supporting curriculum change. However, the authors have also warned of the danger of paying too much attention to ICT infrastructure and sometimes forgetting the

fundamental pedagogical mission of schools. This mission can be overlooked amidst the enthusiasm and the importance given to installing computers in the classrooms. Despite all of the positive effects of integrating ICT into schools, it is crucial to bear in mind that ICT is not to be emphasized as a goal towards which schools are to strive, but rather considered as a tool that can help them to improve and maximize their own performance, and consequently that of their students.

Gudmund Hernes
Director, IIEP

Composition of the Editorial Board

Preface

All systems of education are faced with the introduction, development and maintenance of information and communication technologies (ICT) in schools. The technologies themselves are being developed at an ever-increasing rate. It was at the beginning of the 1980s that many education systems began to introduce computers into schools, with others following suit somewhat later.

What is it that educational planners need to know about the introduction of computers for the first time into schools, and what is it that planners need to know for systems that already have computers in the schools but need to develop the relevant technology and teaching? Some of the questions taken up in the booklet have been presented below to give a flavour of the content:

For pupils and schools and the system:

- To what extent can and should curriculum reform take rapid technological changes into account?
- What contributions can ICT make to the changing roles of pupils and teachers in schools?
- How much of the traditional curriculum needs to be dropped to make space for new content and processes?
- What kinds of equipment and what amounts are needed?
- What are the features of the ICT infrastructure that are crucial for smooth and safe e-traffic?
- What guidelines are needed to help e-travellers to find their way around the Internet, and who can maintain the system?

For teachers:

- Which new kinds of skills do teachers need for dealing with ICT?

- Which conditions must be in place if staff development in ICT is to be successful for making an impact on practice?
- Which models of staff development have been adopted since the mid-1990s?
- Which school conditions are important if ICT is to succeed?

For national policies:

- What kinds of policy goals need to be pursued?
- Which implementation strategies have been used, and which appear to be effective?
- What are the main issues and challenges that need to be considered when formulating national policies for ICT?

These are the kinds of issues that all countries face – whether they are countries just beginning to introduce ICT into schools, or are in the second stage of development having had ICT for 10 or more years and are considering further development. In both cases, the use of ICT in education is still evolving and there are no hard and fast guidelines available. Nevertheless, it is important that educational planners dispose of a state-of-the-art account of what is known, even in an evolving field. All planners are confronted with the task.

The IIEP was fortunate to have Hans Pelgrum from the Netherlands and Nancy Law from Hong Kong undertake the difficult and challenging task of summarizing what is known. Both participated over a number of years in the IEA 'Computers in education' and SITES research programmes, and Nancy Law has had experience in meeting with the implementers of such programmes in many countries. We thank them for their efforts.

T. Neville Postlethwaite
Co-General Editor

Contents

List of abbreviations

ACEC	APEC Cyber Education Cooperation
ACEID	Asia-Pacific Centre of Educational Innovation for Development
ACER	Australian Council for Educational Research
APEC	Asia-Pacific Economic Cooperation
ASCD	Association for Supervision and Curriculum Development
BBC	British Broadcasting Corporation
CERC	Comparative Education Research Centre
CERI	Centre d'études et de recherches internationales
CRIDALA	Conference on Research in Distance and Adult Learning in Asia
ERT	European Round Table of Industrialists
ICT	Information and communication technologies
IEA	International Association for the Evaluation of Educational Achievemen
IEARN	International Education and Resource Network
ISTE	International Society for Technology in Education
IT	Information technology
ITP	Information technology productivity
NCATE	National Council for the Accreditation of Teacher Education
OECD	Organisation for Economic Co-operation and Development
OERI	Office of Educational Research and Improvement

PCAST	President's Committee of Advisors on Science and Technology
SITES	Second Information Technology in Education Study
TIMSS	Third International Mathematics and Science Study

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I. ICT in education, some major concepts and a short historical overview

This opening chapter presents some of the main concepts and issues that need to be considered when looking at the introduction of information and communication technologies (ICT) into education systems. It is illustrated with information that was collected in international comparative studies conducted by the International Association for the Evaluation of Educational Achievement (IEA), and supplemented with findings from other research.

Introduction

The issue of 'computers in education' started to become popular in educational policy-making in the early 1980s, when relatively cheap microcomputers became available for the consumer market. Stimulated by governmental policies, and quite often led by the fear of losing the technology race, many countries started to build their own brand of microcomputers (BBC, Acorn, Tomson) and distributed these to schools. Later, near the end of the 1980s, the term 'computers' was replaced by 'IT' (information technology), signifying a shift of focus from computing technology to the capacity to store and retrieve information. This was followed by the introduction of the term 'ICT' (information and communication technologies) around 1992, when e-mail started to become available to the general public.

With regard to the early introduction of microcomputers in education, there were high expectations that it would make education more effective and motivating. However, when many surveys had shown that computers were used mainly as a supplement to the existing curriculum and much less as tools that were fully integrated in the learning of traditional subject matter, the general feeling among many policy-makers was one of great disappointment. Between 1992 and about 1995, the investments in hardware, staff development and

research programmes on ICT decreased. However, when the World Wide Web became available, the political interest in ICT was quickly boosted for a second time. This interest was accompanied by a commonly accepted rhetoric that education systems would need to prepare citizens for lifelong learning in an information society. This rhetoric can be characterized as follows:

1. As a result of ICT, many societies will change into information societies[1];
2. Citizens in these information societies will need new competences that have not yet been (or that have been, though insufficiently) targeted and attained in the traditional education systems; and,
3. Educational innovations aimed at attaining these new skills (with the help of ICT) and at finding a new balance between old and new educational targets are needed.

According to the above, education needs to become more focused on creating opportunities for students to acquire new skills (related to autonomous learning, communication skills, authentic problem solving, collaborating in teams via various synchronous and asynchronous communication technology, etc.). Furthermore, it has to take place in a school system that emphasizes student self-direction and responsibility in the learning process.

Since the end of the twentieth century, many governments have been undertaking initiatives to innovate education. A common underlying rationale has been the following:

1. In the knowledge society, the half-life of knowledge will become progressively shorter;
2. Due to the growing specialization of knowledge, it will be increasingly necessary to work in teams;
3. Citizens need to be prepared for lifelong learning and be introduced to the basics of team- and project-work as part of basic education;

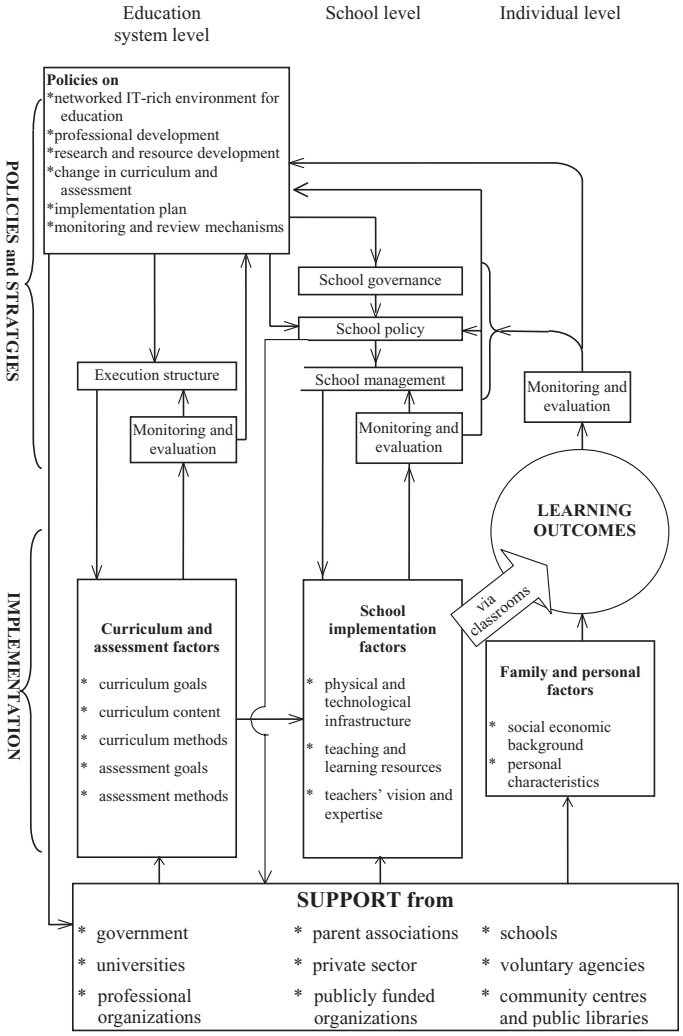
1. The term 'information society' is often associated with other terms such as 'knowledge economy', 'learning society', etc. Although these terms have different connotations, e.g. 'knowledge' as a trade product or 'continuous learning' as a basic prerequisite for leading a private and professional life, in this booklet, for the sake of simplicity, these terms will be used as synonyms.

4. Educational innovations in basic education are necessary if these new demands are to be met, and such innovations should have a strong pedagogical focus on student-centred and increasingly student-directed didactical approaches facilitated by ICT, whereby teachers should play more of a coaching role.

This implies that, unlike the situation in the 1980s, when technology was mainly introduced in education as a new school subject by which students could learn *about* technology, ICT should more appropriately be conceptualized as a facilitator for major education reforms involving changes at the system level (national or regional as the case may be), the school level, as well as the classroom level. The nature of change that the introduction of ICT into the school curriculum brings about may be conceptualized from the perspective of an education system, as illustrated in *Figure 1.1*.

For each of the key aspects in leading change associated with ICT in education, as presented in *Figure 1.1*, a number of important questions relevant for educational planning will be briefly discussed in the sections below. It should be noted that while efforts have been made to draw on research conducted in low- and middle-income countries, much of the evidence from international research and document analysis that is presented throughout this booklet draws heavily upon sources mainly from high-income countries. Since the 1990s, these countries have invested substantial funds to finance the introduction and expanding use of ICT in schools on the basis of expectations regarding the added value of ICT for education. For low- and middle-income countries, the experiences of these forerunners may be of crucial importance to explore the realized benefits of integrating ICT in education, the potential scenarios that may be considered, as well as the pitfalls that are likely to be encountered during implementation.

Figure 1.1 A systems model of leadership and change for ICT implementation in education



Source: Law, 1998: 33.

Curriculum

The term 'curriculum' in this booklet denotes the contents and processes of learning in schools (the intended and implemented curriculum) as well as the outcomes of learning (the attained curriculum). In some education systems, curriculum content is centrally prescribed in great detail, while in other, more decentralized systems, only global guidelines are given, relegating the more concrete details to local levels of decision-making.

Three distinctive roles are generally differentiated for ICT in the curriculum: 'Learning about ICT', which refers to ICT as a subject of learning in the school curriculum, such as computer (or ICT) literacy, computer science and information literacy; 'Learning with ICT', which refers to the use of ICT, including multimedia, the Internet or the Web, as a medium to enhance instruction or as a replacement for other media without changing the beliefs about the approaches to, and the methods of, teaching and learning; and 'Learning through ICT', which refers to the integration of ICT as an essential tool into a course/curriculum, such that the teaching and learning of that course/curriculum is no longer possible without it.

Policy orientations and implementation strategies for ICT integration into the curriculum will be greatly affected by the extent to which the curriculum emphasizes or implies particular pedagogical approaches, such as guidelines for allocating time to autonomous learning, working in projects, etc. For instance, when curricula are traditional in content and processes (with primary emphasis on reproductive skills and whole-class teaching, where all students work in the same sequence and at the same pace), ICT use will probably be restricted to very structured activities under the direction of teachers (as whole-class instructional support or remediation activities by individual students), without much room for exploration by students. When curricula contain prescriptions of content and processes with regard to ICT – such as compulsory ICT courses in the school curriculum – or when examination guidelines specify explicitly the use of ICT, some uses of ICT by teachers and/or students may be stimulated or inhibited. On the other hand, more student-directed

learning methods would require different forms of ICT use to support newer forms of pedagogy, and would require teachers to be proficient not only in ICT, but also in new pedagogical approaches. The extent to which ICT is intended for use in the core curriculum or in extra-curricular activities will impact on policy decisions regarding adaptations that may be required in the formal curriculum.

Probably one of the most pressing concerns for educational planning is to assess the impact that ICT has had on students' learning outcomes (including, but not limited to, knowledge of ICT and of subject content) by the time they leave school. This question is extremely difficult to tackle and answer. While methodologies for measuring outcomes as specified in a traditional curriculum are reasonably well understood and accepted, new pedagogical approaches, as implied by the lifelong learning rhetoric, require new methodologies that have to be developed almost from scratch when their applications in basic education are considered. The traditional methodology capitalizes heavily on standardized measures, whereas new pedagogies require assessment methods that are context-sensitive such that students' abilities to solve authentic problems can be evaluated. The major questions related to student outcomes are:

1. Which student outcomes are the most important for life in the twenty-first century?
2. What would count as evidence of the impact of ICT use on student achievement?

When planning ICT-related curriculum revisions or reform, the following questions need to be considered:

- To what extent can and should curriculum reforms take into account the rapid technological changes in ICT?
- What contributions can ICT make in relation to the changing roles of students and teachers in educational settings?
- To what extent is the rhetoric of lifelong learning (and its associated educational implications) adopted by educational practitioners?
- How much of the traditional curriculum needs to be dropped to make space for new content and processes?

These questions and related issues will be discussed in *Chapter 2*.

ICT infrastructure

ICT infrastructure, as discussed in this booklet, refers to hardware, software and network connectivity. In discussing ICT infrastructure, the assumption has been made that ICT is used not only to support 'learning about ICT', but also to support 'learning with ICT' and 'learning through ICT' as described in the previous section.

Collis (1997) distinguished several important dimensions in the classification of ICT infrastructure in education:

(a) the stand-alone versus distributed dimension: if software is only locally available (most typically on a local CD-ROM) or accessible from remote locations (generally, this will be via web-based systems, intranet or Internet);
(b) the producer versus consumer dimension: if the digital materials are being made by the children and teachers themselves, or if they are made by others and accessed by the children and their teachers; and
(c) the structured versus learner-controlled dimension: the degree to which a pre-determined learning route is designed into materials (tutorials and some simulations) versus their being used as exploratory environments or as hyperlinked encyclopedias of resource materials.

Several questions may arise when the planning of educational resources in education is concerned, such as:

- What kind of equipment is needed, and how much?
- What are the features of the ICT infrastructure which are crucial for smooth and safe e-traffic?
- What guidelines are needed to help e-travellers to find their way around the Internet, and who will maintain this system? Note that the analogy of 'traffic signposts' is quite applicable in this context.

The answers to these questions depend, among other factors, on the content of the other components in *Figure 1.1*. For example, if there is a strong emphasis on ICT-supported, student-centred learning in the curriculum, this will have important implications for the required quantity, functionality and location of the equipment that a school should potentially possess in addition to the access students have to ICT in their homes. The willingness and readiness of teachers to integrate ICT will also be a crucial factor.

In *Chapter 3*, these and other questions will be reviewed on the basis of international assessments of the educational ICT-infrastructure developments that took place during the 1990s and early 2000s in a number of countries around the globe.

Staff development and support

Teachers play a crucial role in the adoption and implementation of ICT in education since they are the key to making learning happen. Earlier studies (e.g. Pelgrum, 2001) have reported teachers' lack of ICT knowledge and skills to be a major obstacle to implementation, and consequently pointed to the need for further training for teachers. It is important to recognize that the introduction of computers into schools is much more complicated than the introduction of new educational technologies. It is a complex innovation which poses considerable challenges to teachers in their daily work. Education reforms, as implied by the rhetoric that was described at the beginning of this chapter, require teachers to adopt new roles as more responsibilities for learning are given directly to the students. This change requires that teachers be proficient in advising and guiding students through more autonomous, self-directed learning processes, while at the same time monitoring the curriculum standards achieved by students. Preparing teachers to take on these new roles is a major challenge for staff development, which includes both initial teacher education and continuing professional development. They must be given opportunities to regularly update their ICT knowledge and skills as well as to exchange their views on changing curricula and pedagogical practices with the integration of technology into education.

While teachers are often the focus of staff development provisions, they are not the only stakeholders that require staff development to cope with the introduction of ICT into schools. First of all, the presence of large quantities and varieties of ICT equipment in schools has created the need for dedicated technology co-ordinators and technical support staff. The availability of support, both technical and pedagogical, is vital for the successful implementation of ICT.

Another important aspect of staff development that must not be overlooked is that of the development of ICT-related educational leadership, especially in the context of professional development for school principals, as they play a crucial role in organizational change and leadership. Specifically, principals make decisions related to the deployment of resources (including infrastructure and staffing) and staff appraisal within the school. Some countries give professional development for principals top priority in their national ICT implementation strategy.

The main staff development and support issues to be addressed in the context of educational planning are:

1. Which are the new teacher capabilities implied by the current ICT-related reform rhetoric?
2. What are the main ICT implementation obstacles related to staff development?
3. Which conditions need to be fulfilled if staff development is to have an impact on practice?
4. What models of staff development have been adopted in recent years?

Organizational change and leadership

As is true of any change that would have significant impacts on educational practice, the change has to be aligned with other institutional priorities if it is to be successful. However, case studies of ICT implementation in schools in a number of countries have indicated that the vision and goal of the implementation can be very different, even for schools that have been actively engaged in innovating their

traditional educational practices (Law *et al.*, 2000; Lankshear, Snyder and Green, 2000; Mooij and Smeets, 2001). It might be expected that changes which do not involve challenges to the existing educational priorities or beliefs of the school would be relatively easily implemented. However, the case studies reported by Law *et al.* (2000) and Lankshear *et al.* (2000) indicate that where the implementation of change involving the integration of ICT in the school was not related to the wider socio-economic context, such implementations may not be successful. In fact, to bring about the kind of curriculum change outlined in the rhetoric requires drastic changes in teaching practice, school culture and organizational management. Schools need to become 'learning organizations', i.e. institutions that anticipate new challenges and change, and orientate themselves towards continual renewal and improvement. Therefore, the following main questions will guide the treatment of this topic in *Chapter 5*:

1. Which main organizational challenges can be anticipated if schools are to become effective nurturing grounds for lifelong learning?
2. What are the key characteristics that schools need to adopt in order to become learning organizations?
3. What are the specific leadership issues to consider if ICT is to be successfully implemented in the curriculum to support and sustain curriculum innovation?

National educational policies and ICT implementation strategies

As illustrated above, there are many issues that require consideration when describing how the role of ICT in education is currently conceived. In recent years, many governments throughout the world have adopted plans that have, to varying degrees, addressed the issues described above. These plans, which are reviewed in *Chapter 6*, are largely similar in their intentions regarding the major direction of change, and are essentially plans for reforming education from a system which is mainly teacher-directed to one that encourages more student-centred learning. However, the nature and scope of the strategies for initiating, guiding and implementing these policy plans differ between countries, partly as a consequence of varying socio-

economic circumstances. The following issues are also addressed in *Chapter 6*:

1. What kinds of policy goals have been pursued?
2. What are the implementation strategies that have been used in various countries at the national level to promote the use of ICT in the curriculum?
3. What are the issues and challenges that policy decision-makers need to consider when formulating their national ICT-in-education policies and strategies?

Looking into the future

This monograph concludes with a chapter that attempts to make some projections into the future about the kind of goals and implementation strategies that are likely to be useful for the short to medium term (up to 2015) in two broad contexts: systems that have already attained some level of success in ICT implementation in education, and systems that are at the very beginning stage of ICT implementation.

II. Curriculum

In this chapter, curriculum issues that are important to consider in relation to ICT in education will be described, together with a conceptual review of the indicators that can be used to judge the extent of the adoption of learner-centred pedagogical approaches. Finally, possible implications for educational planners will be discussed.

Introduction

The aims of this chapter are firstly to describe the meaning of what is often referred to as 'the new educational paradigm' (Pelgrum and Anderson, 2001), and secondly to offer, on the basis of empirical data from an international comparative assessment, an evaluation of the extent to which educational practitioners are ready to adopt this new paradigm. This will be followed by a discussion on how the current, relatively fuzzy definitions of the new educational paradigm can be further clarified.

What policy documents say about an emerging educational paradigm

In most educational institutions, the organization of the learning process can be characterized as being predominantly 'teacher controlled': usually the teachers (or lecturers) fully regulate the learning process. If education is to provide an adequate preparation for the future (the information society), schools must empower learners to become more active and more responsible for arranging their own learning process. Learning has to become more student-directed, as learning needs to continue not only beyond compulsory schooling, but more importantly as a lifelong enterprise. Only through student-directed modes of learning can learners acquire 'productive' skills, problem-solving skills, independent learning skills and/or skills for lifelong learning. Learning has to be organized in such a way that

learners can learn how to become (more or less) architects of their own learning processes, with the help of professional coaches (teachers and others). Voogt and Odenthal (1998), among others, listed, on the basis of an extensive literature review, the following potential features of the education of the future (as compared to traditional education):

Goals and contents

1. Information, investigation, communication, and social skills, as well as meta-cognitive skills, will be emphasized to a greater extent;
2. School subjects and parts of school subjects will be combined with each other so that their boundaries will dissolve;
3. The learning content will be adjusted to become more relevant to real life contexts;
4. Students' performance will be assessed with a greater diversity of methods (open test methods, portfolios, diagnostic and summative tests).

Roles of teachers

1. Teachers will use more instructional methods that are aimed at stimulating active learning (group and individual assignments, practical work);
2. Teachers will focus their actions more on the individual interests and needs of students;
3. Teachers will provide guidance to students when they co-operate in projects;
4. Teachers will share responsibility with students for decision-making in the learning process.

Roles of students

1. Students will be more active;
2. Students will be more independent (planning their own learning path);
3. Students will be more responsible for their own learning (planning and monitoring their own progress);
4. Students will work more in teams.

Materials and infrastructure

1. ICT applications will be more user-oriented;
2. A study planner will be used, promoting independent learning;
3. Physical environments will be made suitable for learning either individually or in small groups;
4. Learning will be flexible in terms of time;
5. Learning will be flexible in terms of location;
6. Multidisciplinary teams of teachers will work together.

According to this review, the learning process will become one of active knowledge construction rather than passive acquisition, more strongly social than individual in nature, and less focused on specific content and contexts, as these are prone to change with time. There will be more emphasis on independent and self-directed modes of learning, in which good self-regulation is important.

The terms 'teacher-controlled' and 'student-directed' are used to highlight the actor who is most active and responsible for making decisions and arrangements pertaining to the learning process. These two terms do not represent two absolutely distinct states of learning organization, but rather the opposite extremes along a continuum. Both teacher-controlled approaches and student-directed approaches have many different manifestations, and, in an information society, a new balance between the two is needed.

New pedagogy in educational practice

In view of the many initiatives that were undertaken by national governments, one may expect that some would (ultimately) result in visible changes in educational practice. In order to determine the developmental trends in educational practice, one needs to monitor nationally representative samples of schools, teachers and students. For this purpose, the data collected in 1998/1999 in an international comparative study by IEA[2] regarding indicators of 'pedagogical practices and ICT' from national samples of schools (at the primary,

2. The International Association for the Evaluation of Educational Achievement (www.iea.nl).

lower secondary and upper-secondary level) in 26 countries may be of particular interest. During the 1990s and early 2000s, there have been no other international agencies that have conducted quantitative assessments on ICT and pedagogical approaches in education. Therefore, hardly any trend data on pedagogical practices related to ICT are available. Hence, the baseline data collected between the end of 1998 and the beginning of 1999 are the earliest international data available. One potential source for gaining an impression of developmental trends, albeit at a national level, is the Dutch ICT monitoring programme (Pelgrum and ten Brummelhuis, 2001). In this monitor study, data on ICT indicators (in many different areas such as infrastructure, pedagogical approaches and staff development) were collected each year (since 1998) from national representative samples of school principals, ICT co-ordinators, teachers and students. Results from the qualitative studies conducted by IEA and OECD on ICT-related innovations in education (Kozma *et al.*, 2003; Venezky and Davis, 2002) will also be considered below to provide further insight on this issue.

The data from IEA and the Dutch ICT monitor will be used to address the following questions[3]:

1. To what extent are educational practitioners aware of, and willing to adopt (elements of) a new educational paradigm?
2. To what extent is ICT facilitating the implementation of (elements of) a new pedagogical paradigm?
3. What are the obstacles to realizing the ICT-related objectives of schools?
4. What expectations exist for the (near) future?

Awareness and adoption

From the data collected in SITES[4], as well as in the Dutch ICT monitor, there were clear indications that the policy discussions had

3. For brevity's sake, the focus in this section will be on lower-secondary education.
4. SITES stands for Second Information Technology in Education Study, a worldwide assessment of the use of ICT for learning (Pelgrum and Anderson, 1999). The study consists of three modules: Module1 (M1) – surveys of schools; Module 2 (M2) – case studies of ICT-supported innovative pedagogical practices; Module 3 (M3) – surveys of schools, teachers and students.

also affected educational practitioners. In the SITES study, school principals were asked to write down their most satisfying experience with ICT in terms of – amongst other factors – content, student activities, and what teachers and students gained from such activities. From the analysis of these data (Voogt, 1999), it appeared that:

> "Quite a number of school principals across countries reported on the contribution that ICT made to new curriculum approaches (such as cross-curricular[5]), different roles for teachers, and productive learning activities for students" (p. 215).

Another observation stems from the Dutch ICT monitor, which included questions addressed to school administrators and teachers about their expectations for the future with regard to the characteristics of teaching and learning. Two indicators were constructed on the basis of the respondents' judgements of the current and future relevance of certain practices listed under the two headings below:

Teacher-controlled teaching and learning:

- Testing the whole class at the same time;
- All students start with new content at the same time;
- Students are given fixed seating arrangements;
- Whole-class teaching;
- All students work at the same time and study the same material;
- The teacher is the most important source of information.

Student-controlled teaching and learning:

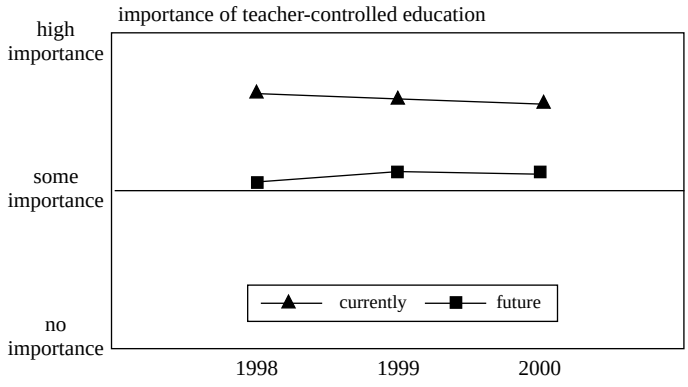
- Students frequently apply self-monitoring;
- Students work at their own pace;
- Students work in groups or individually;
- There are enough work places for group work;
- There are separate work places for group work;
- 'At-risk' students are provided with individualized instructions;
- Instructional materials are available for student consultation within the classrooms.

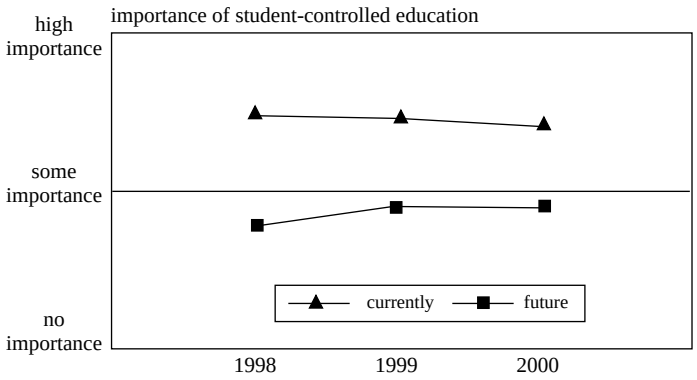
5. That is, approaches that are multidisciplinary and address content from several school subjects at the same time.

From the results (see *Figure 2.1* for illustration), it is apparent that Dutch teachers (at secondary level) not only perceived teacher-controlled education as the main characteristic of the current educational settings, but that they also expected student-directed education to be much more important in the future. The same comments were made by Dutch school principals on the same two sets of items.

From the above statements, one may tentatively conclude that there appeared to be an awareness, and even a willingness among Dutch educational practitioners to accept the importance of student-directed learning. However, it should be noted that as yet, these indicators do not seem to change quickly over time.

Figure 2.1 Indicators of Dutch teachers' perceptions (in three consecutive years) of the relevance of teacher-controlled and student-directed education, now and in the future





Source: Pelgrum and ten Brummelhuis, 2001.

A next question is: to what extent have student-controlled learning practices already been adopted in schools? The data from SITES may shed some light on this question. School principals from lower-secondary schools in 24 countries were asked about objectives, presence and ICT facilitation of a number of pedagogical activities that are potentially indicative of student-directed learning. Here, for the purpose of our presentation, the focus will be on the extent to which schools have adopted pedagogical practices that reflect independent learning by students.

Table 2.1 Percentages of school principals (in lower-secondary schools) answering affirmatively to questions about policy, presence and ICT facilitation with regard to independent learning by students

	Policy to encourage	Widely implemented	Realized a lot with ICT
Country			
Belgium-French *	62	28	7
Bulgaria	71	45	21
Canada *	70	46	28
China Hong Kong	85	4	13
Chinese Taipei	80	22	30
Cyprus	67	27	40
Czech Republic	65	15	24
Denmark	68	44	16
Finland	92	27	15
France	78	20	13
Hungary	82	65	39
Iceland	82	8	5
Israel *	92	20	34
Italy *	72	24	10
Japan	67	5	12
Lithuania	89	24	16
Luxembourg	62	16	12
New Zealand *	75	39	12
Norway	87	64	16
Russian Federation *	33	31	13
Singapore	89	15	25
Slovenia	90	46	15
South Africa *	66	38	16
Thailand	62	37	24

* Country did not satisfy all guidelines for sampling.
Source: Adapted from Pelgrum and Anderson, 2001.

Table 2.1 contains the percentages of school principals (at the lower-secondary level) per country who answered that it was their school's policy to encourage independent learning by students. Also included is the percentage of school principals who indicated that independent learning was already an important learning method in

their school. One may observe in this table that in many schools, independent learning by students was claimed to be a policy goal of the schools. At the same time, in quite a number of countries, a substantial number of schools indicated that this policy was perceived as being widely implemented. The last column indicates to what extent school principals attributed an important role to ICT for the realization of this type of learning activity. Although these figures are a little difficult to interpret (ICT can contribute greatly to the realization of student independent learning, even in cases where this is not widely implemented), it is noteworthy that there were some countries where these percentages were quite substantial, which may be taken as an indication that school practitioners were becoming aware of the potential added value of ICT.

From the above, one can tentatively conclude that the notion of student-directed pedagogy was starting to be adopted in educational practice and implemented in a substantial number of countries at the end of the previous millennium. While such implementation was not yet realized on a large scale, the change was substantial enough to be taken as an indication of reforms that may take place in the first decennia of the new millennium.

Implications for the intended, implemented and attained curriculum

An important question for educational planners relates to the implications that the pedagogical changes described above may have for the curriculum. One may argue that a change of curriculum goals towards putting more emphasis on acquiring competences for autonomous learning may have consequences for timetabling in schools. Realizing new competences takes time, and therefore it seems reasonable to expect that less time will be available for the traditional curriculum. This may have consequences for the traditional curriculum standards and examination programmes, etc. There are several indications from recent studies that time re-allocations will be needed. A first example comes from Singapore, where it was determined "that to facilitate the development of such a learner-centred environment (supported by the availability of technology and digital resources) a 10 to 30 per cent reduction of curriculum content was instituted towards the end of 1998" (Teng and Yeo, 1999).

Indicators of the pedagogical impact of ICT may also be inferred from observations that were recorded in the qualitative case studies component of SITES, in which cases were explicitly selected (by national panels) because they reflected an orientation towards pedagogical reform. These observations confirm the enthusiasm of teachers and principals about the characteristics of these innovations, as can be inferred from statements that were made in many case reports:

Improved student outcomes, with regard to:

- motivation, enjoyment in learning;
- self-esteem;
- ICT skills;
- collaborative skills;
- subject-matter knowledge;
- information handling skills;
- metacognitive skills.

Improved teacher outcomes, with regard to:

- self-confidence/self-esteem through peer recognition;
- ICT skills;
- pedagogical skills and/or other professional competences;
- collaboration with colleagues.

Less common, but still interesting to mention, were the following observations:

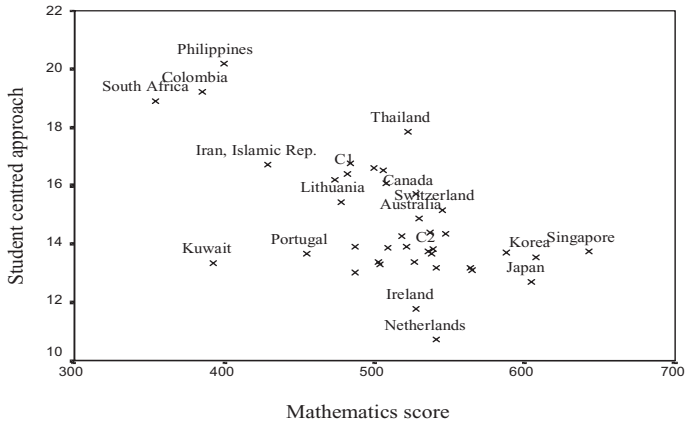
- less discipline and management problems were experienced;
- the relationships between students and teachers had improved;
- teachers were learning a lot from students;
- teachers improved their presentation skills.

Quite often it was (in the absence of objective evidence) believed that students' learning was boosted.

In the majority of cases from SITES Module-2, it appeared that the change in curriculum content was minimal. Instead, schools were

trying to offer the same content in different ways by allowing or stimulating students to work more on their own and in co-operation with peers and with the support of ICT. Sometimes content change in the official school curriculum was not needed because the activities were organized as an extra-curricular option. There were some indications that new activities resulted in better student achievement in the traditionally valued skills, such as reading and writing. However, researchers who conducted the case studies noted that hardly any objective data existed to support these claims. Some teachers reported that the traditionally valued knowledge and skills of students might decline. Such expectations are consistent with the arguments presented above: if curriculum time is re-allocated to foster new competences of students (e.g. co-operation, communication, planning one's own learning process), there may be less time available for developing the traditionally valued competences. Unfortunately, there is not much evidence to support such claims for education at large. However, there are several studies that suggest that a focus on more student-centred pedagogical approaches may be associated with lower student achievement when measured using conventional assessment methods. A first observation comes from Pelgrum and Plomp (2002), who showed that more emphasis on student-centred approaches tended to be negatively associated with student scores in achievement tests that were administered in the Third International Mathematics and Science Study (TIMSS-95), as is illustrated in *Figure 2.2*.

Figure 2.2 Plot of mean values per country for TIMSS-95 mathematics scores, and an index to indicate the level of adoption of student-centred approaches in learning and teaching in those countries



Legend. C1: Cyprus, England, Greece, Hong Kong, New Zealand, Romania, Spain, USA;
C2: Austria, Belgium-Flemish, Belgium-French, Czech Republic, Denmark, France, Germany, Hungary, Iceland, Israel, Norway, Russian Federation, Slovak Republic, Slovenia, Spain, Sweden.

Source: Pelgrum and Plomp, 2002: 317-330.

The authors' comments on the findings were as follows:

"The strong association between student-centred didactics and the use of computers does fit nicely with the currently popular rhetoric regarding ICT, education, and the information society. This rhetoric has been formulated in many policy documents (European Commission, 1995; ERT, 1997; PCAST, 1997), which call for the fostering of lifelong learning together with the use of ICT as one of the cornerstones of the information society. In this rhetoric, a shift from a traditional pedagogical paradigm (teacher-centred, whole-class teaching, etc.) to a paradigm focusing on independent learning (doing projects,

teamwork, etc.) is foreseen, and in numerous documents it is assumed that ICT can facilitate the adoption and implementation of such reform.

"The evidence presented in this chapter seems to suggest that the use of ICT tends to take place in situations in which a somewhat higher emphasis is placed on learner-centred approaches. A tentative hypothesis about the large score difference between the high-computer-use and low-computer-use groups is that this is caused by a pedagogical approach in which less emphasis is placed on competences such as those measured in the TIMSS-95 mathematics tests" (Pelgrum and Plomp, 2002: 328-329).

Angrist and Lavy (2002) also reported negative effects of introducing computers on the arithmetic skills of pupils in Israeli schools. However, the evidence on this issue is still rather anecdotal and needs further continuous monitoring.

There may also be other side effects of introducing new pedagogical approaches in education, as is reflected in the following quotes (extracted from the SITES-M2 database and slightly edited) from educational practitioners that were interviewed:

- Learning: "Students are used to getting information easily using ICT and they don't work so hard on what is required for good learning".
- Using ICT: "Gradually, the students think it is normal to use a computer. Sometimes they do not like to use the Internet ("Again Internet?") One teacher stated that: "I have the impression that many perceive ICT more as a toy than as a tool".
- Planning: "The students felt that the first part of the project, the planning phase, took too much time, and that they got bored. As one of the students said: 'I didn't like the planning phase. It was too much theory. It was much more fun when we started to work on the bathrooms and saw some results'".
- Teacher workload: "It takes a lot of preparation time. It contributed to burn-out of teachers".

The potential impacts of the education reform movement deserve further in-depth investigation in future research, as the statements quoted above illustrate.

How ICT is supporting curriculum change

From the experiences collected in SITES-M2, it appears that ICT has added value to support learning environments that are more student-controlled than traditionally has been the case. Teachers reported that students were very motivated and that discipline problems disappeared. Also teachers themselves said that, even despite heavier workloads as a result of preparing for the new learning arrangements, they found the classroom atmosphere much more relaxed, they enjoyed being better acquainted with their students, and reported to have experienced improved co-operation with colleagues, which was very stimulating.

Implications for educational planners

A number of implications for educational planning may be inferred from the above observations.

When the integration of ICT in educational practice is a major policy goal, it needs to be embedded in an explicit pedagogical rationale. The case studies that were conducted in SITES-M2 suggest that innovations are possible if there is a willingness among educational planners and practitioners to change curricular goals. The current reforms are still mainly dependent on the enthusiastic early innovators, who often have to invest much of their private time to developing and implementing the innovations. However, innovation of the education system at large requires changes in the curriculum, which will need to be established in the intended curriculum at the supra-school level in most countries. (In some countries, intended curricula may be determined at national levels, while in others these may be at regional, district or federal levels, etc.) To implement changes implied by the intended curriculum, facilitating measures are necessary. These include continuous staff development, national educational web portals for sharing resources and experiences associated with the introduction of authentic and challenging ways of learning, as well as tools to support and monitor students as they engage in independent, self-regulated learning activities, any time, anywhere.

III. Infrastructure

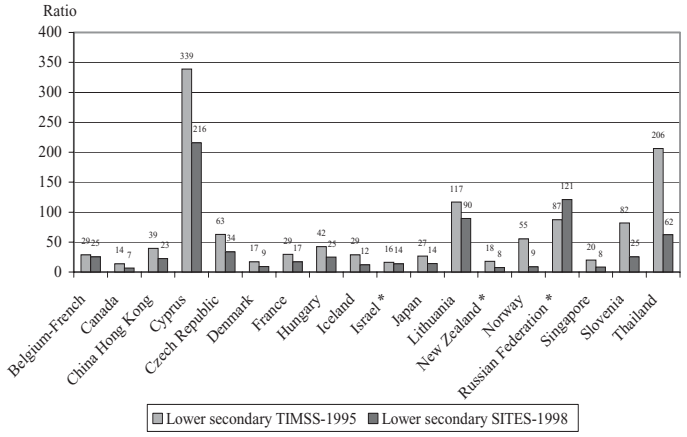
This chapter presents some indicators that describe the available infrastructure in a large number of countries all around the world. The final part of the chapter is devoted to discussing questions that are relevant for educational planning.

Introduction

From international comparative surveys that were conducted at the end of the 1980s, one may conclude that a large-scale introduction of computers in education started in many industrialized countries around 1985. This was the time when relatively cheap microcomputers became available for the consumer market. In and around 1990, student:computer ratios of approximately 30 were quite common. However, during that decade, schools in many countries were equipped with increasing numbers of computers, which often resulted in drastic declines in the student:computer ratios, as is illustrated in *Figure 3.1*.

Towards the end of the 1980s, computer equipment was still rather user-unfriendly and required, for operation and maintenance, a relatively high level of technical skills. During the 1990s, with the appearance of the Windows® environment, technology became more accessible and manageable. This, together with the advent of the Internet and the World Wide Web, helped to popularize the use of computers among the general public. Connectivity became an important issue and, as will be further discussed in *Chapter 6*, many governments adopted plans to connect schools to the Internet and to upgrade the available equipment in terms of quality (including multimedia capabilities for creating and retrieving pictures and sound) as well as quantity: a student:computer ratio of 10 or less was an explicitly formulated goal in many policy documents.

Figure 3.1 Comparison of student:computer ratios in 1995 and 1998 for lower-secondary education (includes all schools: computer-using as well as non computer-using)



* Country did not satisfy all sampling criteria. Estimates are for all schools, that is, including non computer-using schools.
Source: Pelgrum, 1999*b*: 125.

In this chapter, a review is provided on what is known about indicators of ICT infrastructure in education. These indicators were derived from assessments in which the authors were involved, as well as from other sources.

Quantity and quality of hardware

The student:computer ratio is conceived as an indicator of the availability of computers, whereas the average percentage of multimedia machines (defined as "computers equipped with a CD-ROM and a

sound card") provides an indication of the quality (in terms of the degree of sophistication) of the equipment. These two indicators (which are shown in *Table 3.1*) differed quite considerably between countries as well as between school levels. Both primary and lower-secondary schools in Canada, Finland, Iceland, New Zealand, Norway and Singapore were relatively well equipped in terms of quantity of hardware. The ratios in economically less developed countries were much less favourable. The general trend was that secondary schools had more computers than primary schools. However, the percentage of multimedia computers tended to be higher in primary schools.

By the end of 1998, access to the Internet for all or most schools was available only in some countries, including Canada, Finland, Iceland, Singapore and Slovenia. This does not necessarily mean that most students in these countries used the Internet (see below).

Table 3.1 Indicators of student:computer ratios, percentages of multimedia equipment, and percentages of schools with access to the Internet

	Primary education			Lower secondary education		
Country	Ratio	Multimedia	Internet	Ratio	Multimedia	Internet
Belgium-French*	~	~	~	25	25	41
Bulgaria	~	~	~	238	8	26
Canada*	8	53	88	7	40	98
China Hong Kong	25	90	10	23	81	80
Chinese Taipei	81	55	55	25	35	62
Cyprus	183	69	17	216	44	11
Czech Republic	~	~	~	34	23	33
Denmark	~	~	~	9	47	85
Finland*	12	58	87	10	52	96

France*	25	~	24	17	41	55
Hungary	~	~	~	25	32	41
Iceland	13	58	98	12	60	100
Israel*	16	43	35	14	36	53
Italy*	88	78	28	16	45	73
Japan	28	72	69	14	56	58
Lithuania	~	~	~	90	15	56
Luxembourg	~	~	~	12	16	79
New Zealand*	14	61	77	8	25	89
Norway	13	40	56	9	43	81
Russian Federation*	~	~	~	121	9	4
Singapore	12	96	100	8	98	100
Slovenia	23	49	84	25	48	85
South Africa*	~	~	~	123	25	52
Thailand	~	~	~	62	21	25

* Country did not satisfy all guidelines for sampling.
Source: Adapted from Pelgrum, 1999*b*.

One may argue, on the basis of *Figure 3.1*, that indicators of infrastructure tend to be obsolete by the time they are published. Overall, the average country seemed to be able to reduce the student:computer ratios by slightly more than half between 1995 and 1998. Several of these countries reduced their ratios even more rapidly, probably as a result of national programmes to expand their educational ICT infrastructure. It should be noted that most progress regarding ICT infrastructure was observed in high-income countries. Such observations may be of particular interest to educational planners in weaker economies, because they would allow them to examine (via visits or exchange programmes) the educational and societal benefits of the investments of these forerunners, and to explore how problems

of maintenance and updating of equipment were solved in different educational contexts. Viewed from this perspective, the world is a laboratory where some countries can take the lead in exploring the feasibility of potentially 'risky' operations, while other countries that cannot afford to take these risks may benefit from seeing the positive or negative outcomes of the experiences of these early innovators. By the last decade of the twentieth century, reliable and valid indicators of ICT infrastructure in education became available only occasionally. However it is expected that in subsequent years, indicators of ICT infrastructure will become available more frequently, because these indicators are included in most of the international assessment programmes, including those from the Organisation for Economic Co-operation and Development (OECD) as well as the International Association for the Evaluation of Educational Achievement (IEA).

An important question for educational planners is: what quantity of equipment is considered to be sufficient? In general, this question is difficult to answer because, as illustrated in the conceptual framework that was introduced in *Chapter 1*, there are so many factors that affect the need for particular amounts and functionalities of hardware. However, it may be worthwhile to explore how educational practitioners respond to this question.

The school principals and the technology co-ordinators in secondary schools participating in the Second Information Technology in Education Study (SITES-M1) were given a list of potential obstacles and asked to "*Indicate whether or not you consider each of the following to be* ***major obstacles*** *affecting the realization of your school's computer-related goals for students in Grades * to **[6]". The master list of obstacles contained 38 statements. The collected information was condensed to an average percentage of respondents across all participating countries that checked an obstacle. The result is shown in *Table 3.2*, sorted by descending order of the average percentage.

6. * to * was a grade range specified by each country. This range covered the internationally agreed target grade, plus/minus one year.

As can be inferred from *Table 3.2*, the top 10 obstacles (which happen to score, on average, above 50 per cent) consisted of a mixture of material and non-material conditions. The most frequently mentioned problem was the insufficient number of computers. This problem was already evident in 1989 and 1992 (Pelgrum and Plomp, 1993; Pelgrum, Reinen and Plomp, 1993). Also in the top 10 were other material conditions, such as inadequate peripherals, insufficient copies of software, and a shortage of computers that could simultaneously access the World Wide Web. The second most common problem was that teachers did not have sufficient skills and knowledge regarding ICT. Apparently, most countries had not yet succeeded in providing sufficient opportunities to keep teachers up to date with new technologies (see *Chapter 5* for a further discussion of this issue). Other non-material obstacles in the top 10 were: the difficulties in integrating ICT in instruction, scheduling enough computer time for students, insufficient teacher time, and the lack of supervisory and technical staff.

Table 3.2 List of obstacles sorted by average percentage of respondents across countries

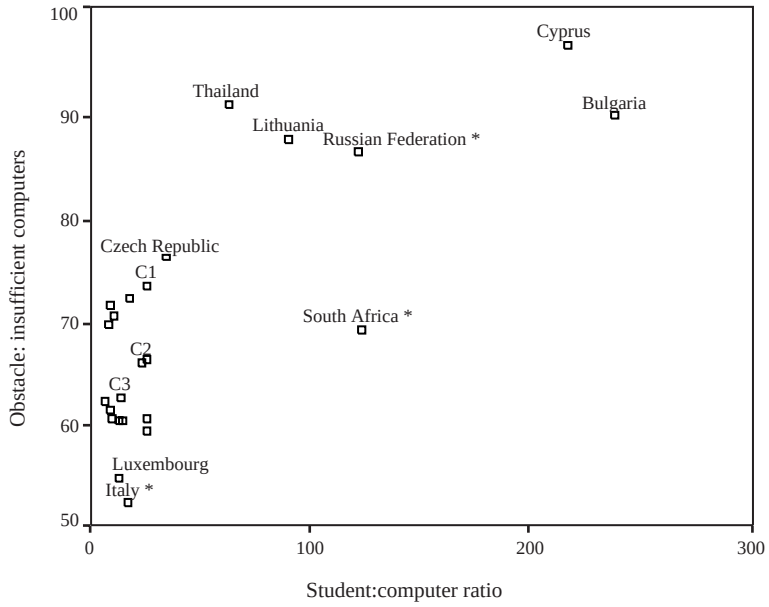
Obstacle	%	Obstacle	%
Insufficient number of computers	70	Quality teacher training too low	31
Teachers lack knowledge/skills	66	Software not adaptable enough	29
Difficult to integrate in instruction	58	Students know more than teachers	29
Scheduling computer time	58	WWW: slow network performance	28
Insufficient peripherals	57	Lack of interest of teachers	27
Not enough copies of software	54	Difficult use by low-achieving students	22
Insufficient teacher time	54	Telecom infrastructure weak	21
WWW: not enough simultaneous access	53	WWW: Difficult finding information	21
Not enough supervision staff	52	WWW: Information overload	20
Lack of technical assistance	51	Software curriculum incompatible	19
Outdated local school network	49	Lack of administrative assistance	19

Not enough training opportunities	43	Software not in language of instruction	18
WWW: no time for teachers to explore	41	Lack of support from school board	17
WWW: no time in school schedule	41	No plan to prevent theft/vandalism	15
Lack of information about software	38	Software culturally incompatible	12
WWW: not enough connections	35	Software too complicated to use	10
WWW: Insufficient technical support	34	Poor quality WWW materials	9
Not enough space to locate	32	WWW: complicated to connect	8
Weak infrastructure (telecommunications etc.)	32	WWW: overloading of mail boxes	4

Source: Pelgrum, 2001.

An interesting question is: to what extent does the mentioning by school principals of the obstacle of 'insufficient number of computers' co-vary with the actual availability of equipment as reflected in the student:computer ratios that were reviewed above? While the results presented in *Figure 3.2* indicate considerable co-variation (the correlation is 0.77) between the student:computer ratio of countries and the percentage of respondents who indicated that the insufficient number of computers was a major obstacle, there seemed to be a strong contrast between countries with student:computer ratios of roughly 20 and higher, and those below 20. Pelgrum (1999*b*) showed that even with ratios of 10 and lower, 50 per cent of the respondents still complained about the lack of computers. Unfortunately, the number of observations (across countries) was too low to further differentiate schools with student:computer ratios below 10.

Figure 3.2 Scatterplot of countries' percentages of respondents checking the obstacle 'insufficient number of computers' and the student:computer ratio per country



Notes: C1=Belgium (French)*, Finland, France, New Zealand*, Norway;
C2=China Hong Kong, Hungary;
C3=Canada*, Chinese Taipei, Denmark, Iceland, Israel*, Japan, Singapore, Slovenia;
*Country did not satisfy all guidelines for sampling.

Source: Pelgrum. 2001: 174.

ICT brings with it widened possibilities for learning that are independent of place and time. Thus another important question related to ICT infrastructure is the extent to which students have access to ICT equipment and communication connections at home. Although survey results indicated that the use of computers at home often did not involve school-related learning, there were indications that students

still learned about new technology, often to a larger extent than they did at school (Pelgrum *et al.*, 1993). Results presented in *Table 3.3* indicate that in a few countries, nearly all students at the lower-secondary level claimed that they had access to computers at home in 1995, while home access was available to only a small percentage of students in many other countries. Comparisons with the more recent TIMSS-99 data revealed that in most countries, home access was also increasing rapidly, which in theory means that the conditions for ICT-supported learning outside school were becoming rather favourable in a number of countries, mostly in the high-income category. The digital divide is becoming visible when considering countries with weak economies, where the changes over the four-year period were small or, in some cases, even negative.

Table 3.3 Percentages of students in the TIMSS Population 2 upper grade (mostly Grade 8) who had access to home computers in 1995 and 1999, and the change (DIFF) between those years

Country	1995	1999	DIFF	Country	1995	1999	DIFF
Japan	—	52	—	Singapore	49	80	31
Scotland	90	—	—	Slovenia	47	66	19
England	89	85	-4	Spain	42	—	—
Netherlands	85	96	11	Lithuania	42	16	-26
Ireland	78	—	—	Korea	39	67	28
Iceland	77	—	—	Portugal	39	—	—
Denmark	76	—	—	Cyprus	39	58	19
Israel	76	80	4	Hong Kong	39	72	33
Australia	73	86	13	Hungary	37	50	13
Germany	71	—	—	Czech Republic	36	47	11
Belgium (Flemish)	67	86	19	Russian Federation	35	22	-13

Switzerland	66	—	—	Slovak Republic	31	41	10
Norway	64	—	—	Greece	29	—	—
Canada	61	85	24	Romania	19	14	-5
Sweden	60	—	—	Philippines	17	15	-2
Belgium (French)	60	—	—	South Africa	15	11	-4
New Zealand	60	72	12	Latvia (LSS)	13	15	2
Austria	59	—	—	Colombia	11	—	—
United States	59	80	21	Iran, Islamic Republic of	4	7	3
Kuwait	53	—	—	Thailand	4	8	4
France	50	—	—				

Source: Pelgrum and Plomp, 2002: 317-330.

Educational content

So far in this chapter the focus has been on hardware as a major component of ICT infrastructure. Although the availability of hardware is an essential condition for being able to use ICT in educational practice, it is obvious that the availability of relevant educational content is crucial too.

Since the early days of introducing microcomputers in education, educational practitioners have found it very difficult to locate educational content suited to particular local needs. This is not to say that relevant, valid and high-quality content does not exist. In particular for countries where English is the native language, a huge amount of educational software is available. This is much less the case in other countries where the market is often too small for educational publishers to invest in the development of educational software. However, even when there is a large supply of educational content, a major problem confronting educational practitioners is the amount of time that is needed to select the materials and to design for its instructional use in

a way that adds value to a particular educational context. Also, having to purchase software before it can be reviewed in detail constituted an additional threshold for schools.

Since the Internet became available for large-scale educational use, it has, in principle, become easier for educational practitioners to get access to educational content. However, it still requires much time investment to locate appropriate content. Although many governments have invested in creating national educational web sites (also called 'portals'), the problem of dissemination for the education community at large has still not been solved. This was also the case with stand-alone educational software: in many countries there is still a serious lack of content available in the native language and which is compatible with the national curriculum. It is to be expected that in the forthcoming decade, substantial investments will be required to make educational practitioners aware of the existence of particular educational content on the web and to identify (with the help of examples of best practices that may exist in languages other than the native one) which needs exist for translating and making available particular content via national educational portals on the World Wide Web. It seems evident that much benefit is to be gained from international co-operation and from building, on the basis of co-operative development and research, a knowledge base of 'best practices'. Such co-operation should probably, for practical reasons, first start at the level of geographical regions or sub-regions. It seems important that such efforts be accompanied by staff development programmes, which would be aimed at acquainting educational practitioners with the content of these knowledge bases and with how to select and adapt best practices to local needs while taking into account curricular and technological constraints.

Implications for educational planners

From the above, one may tentatively infer a number of implications that the development of ICT infrastructure may have for educational planning. A first, rather obvious implication is a financial one: equipping schools and keeping them up to date with ICT equipment is a very expensive operation, not only due to the necessary hardware and software purchases, but also because of recurrent costs associated

with maintenance and support and, especially nowadays, the fees of using high-speed Internet connections. Although the more wealthy countries during the 1990s and early 2000s were able to install great quantities of equipment in schools, the weaker economies were not presented with such opportunities. However, the experiences from the wealthy economies may help also the less advantaged countries to learn about the cost-effectiveness of introducing ICT. A general observation from reviews is that despite the huge investments, ICT is hardly integrated in the daily classroom practices even in the countries that played a forerunner role. One may wonder if ICT infrastructure has been emphasized too strongly in educational policy-making in the past, causing attention to be diverted away from the pedagogical mission of schools. As argued in the previous chapter, ICT is not a goal in itself, but rather a potential tool that may help schools to improve their performance. However, how, and under which circumstances, this can be realized is a matter of continuous exploration, from which 'best practices' will emerge that may be suitable for further (inter)national dissemination. Although the large existing diversities in the world with regard to access to ICT may raise the question of to what extent might this digital divide have consequences for future generations of citizens, the answer to this question not only depends on the available quantity of hardware and digital content, but also on other factors such as curriculum objectives, facilities for staff development, etc.

IV. Staff development

This chapter provides an overview of the human resource challenges to be faced when implementing ICT. Human resource related obstacles, as well as good models of staff development, will be presented.

Introduction

Educational changes, especially those implied by the rhetoric of the information society, require staff development activities. In order for changes to be effected in the classroom, additional technical and pedagogical support is often necessary. The term 'staff' is used in this chapter to mean all those in schools who should contribute to the implementation of the intended changes. These persons are usually school principals, teachers, and technical and administrative support personnel. In this chapter, the main focus is on teachers.

Teachers play a crucial role in the adoption and integration of ICT in education as they are a key element in curriculum implementation and innovation. Teachers who succeed in making use of ICT in their work process do not only contribute to improved learning outcomes in their students, but may also benefit personally from enhanced work productivity, reduced isolation and increased professional satisfaction (Carlson and Gadio, 2002). In the 1992 Computers in Education (CompEd) study on ICT implementation and innovation in 21 education systems, Pelgrum *et al.* (1993) found that many teachers reported a lack of knowledge and a need for further training. In the SITES-M1 study conducted in 26 education systems in 1998, it was also reported that more than half of the school principals in most of the countries surveyed perceived the teachers' lack of ICT knowledge and skills to be a major obstacle for attaining the school's ICT-related goals (Pelgrum and Anderson, 1999). As argued in the previous chapter, the implementation of ICT in schools involves much more than the introduction of new educational technologies.

Rather it aims at bringing about a broad curriculum reform requiring teachers to acquire new skills associated with their changing roles and practices in the learning process. It is a complex innovation which entails considerable changes for teachers. Staff development includes both initial teacher education and regular updating of ICT knowledge and skills, and continuing professional development on changing curriculum and pedagogical practices in the integration of technology into the educational process.

In this chapter, four major points will be examined and discussed. Firstly, what professional development needs do staff members involved in IT have? Secondly, what are the major obstacles to good implementation? Thirdly, what are some model practices that have been successful, and what are the financial implications? And finally, what are the implications of professional development for the various levels of planners in the education system?

What staff development do schools need?

When considering ICT-related staff development in schools, it is important to recognize that the needs are different for different professional roles in schools. In general, four different roles need to be distinguished for this purpose: informatics teachers, subject teachers for various school subjects, technology co-ordinators and school principals. Training for informatics teachers has attracted relatively less attention in recent years from policy decision-makers and researchers alike, possibly because the teaching of informatics has a much longer history, the number of teachers involved is relatively small, and offering informatics as a school subject is no longer the focus of ICT implementation in many countries. The prime focus of staff development in many countries has moved to the training of all schoolteachers so that they can make use of computers in their day-to-day teaching activities, and the necessary staff development for principals and technology co-ordinators to lead and support ICT implementation across the curriculum.

What teacher competences need to be developed?

Many authors have already speculated about the new competences required for integrating ICT into the learning process. These competences include: handling hardware and software, curriculum (re)design, coaching, monitoring, developing digital materials, developing a vision of ICT in education, co-operation with colleagues, etc.

Often, at an early stage of ICT adoption, this training will include the use of common office application programmes, sending e-mails, making use of the Internet, as well as some knowledge about how to make use of computers in subject-based teaching. However, it appears that the competences expected vary according to the prevalent pedagogical culture of the education systems concerned. For example, in countries with a Confucian Heritage Culture (Biggs, 1996), where teaching tends to be very much teacher-led around well-defined content, teacher training also includes the production of multimedia course materials. For example, in Hong Kong it is expected that the more competent teachers produce electronic presentations and course materials for classroom use (Education and Manpower Bureau, 1998).

Some countries have set up some form of 'IT driving licence' for both students and teachers, prescribing the minimum ICT competence expected (e.g. NCATE, 1997; ISTE, 1998; EURYDICE, 2000). The attainment of certain targets according to a prescribed timeline may also be formulated as an expectation (as in the case of Hong Kong and Singapore) or a requirement[7] for teachers who wish to remain in the profession. The implementation of such measures can obviously only be possible where there have been adequate provisions of training opportunities for teachers.

7. For example, most states in the USA have requirements regarding IT literacy standards for initial licensure for entry into the teaching profession, and NCATE (National Council for the Accreditation of Teacher Education) has issued ICT-related guidelines that schools of education must meet before they receive accreditation (NCATE, 1997).

Developing teachers' ICT competence is the first, but not the most important step in teacher professional development in the information age. It is also widely recognized that teachers need to know how to make use of ICT in pedagogically meaningful ways in the school curriculum (e.g. Finnish National Fund for Research and Development, 1998). Many ICT-related educational policy goals also recognize the need to promote changes in the roles played by teachers and learners such that learners can become more self-directed and autonomous. Such changes in the learning and teaching process have generally been described as emerging pedagogies of the information age (Pelgrum and Anderson, 1999). It has also been found that in instances where the goal of ICT implementation is to support the development of emerging pedagogies, the provision of teacher professional development programmes would focus strategically on helping teachers to develop new pedagogical approaches and skills, as well as the ability to design new learning activities (e.g. Singapore Ministry of Education, 1997).

As the world moves towards an ever more global, more knowledge-based economy, many societies are also experiencing a change in the profile of human resource abilities needed for sustaining growth and development (Riel and Fulton, 2001). As knowledge creation and dissemination are perceived to be of paramount importance, the goals and processes of initial schooling should change to include the development of learners' lifelong learning abilities as a main objective (ERT, 1997). A survey conducted for the APEC Education Ministerial Meeting at the end of 1999 found a major and most prominent theme emerging from the responses of 13 member economies: the teacher of the future is one who facilitates and models learning, and who is innovative and willing to learn along with students.[8] It was expected that teachers would need to understand the influences of culture and language, and be able to assess and accommodate individual learning needs. Teachers will need to be more innovative and willing to take risks in the classroom, and they will also need to be more collaborative in their work. The same paper also put forward the view that what

8. Improving Teaching Systems, a main paper for the 2nd APEC Education Ministerial Meeting 'Education for learning societies in the twenty-first century', 7 April 2000. http://aemm.moe.edu.sg/asp/asp_aemmpaper/aemmpaper.asp

teachers should know, and how training should be delivered, need to be reformulated so as to make training a continuous process rather than a series of unrelated activities or experiences. This recognition of the need for teachers to assume new roles and for staff development programmes to foster such changes is found in the national-level documents on ICT in education around the world, for example PCAST (1997) and the Danish Ministry of Education (1997).

In systems where there is a longer history of ICT use across the curriculum, professional development programmes focus more on links between ICT use and classroom practice. It is interesting to note that Finland is relatively unique in linking its in-service training programme for teachers very firmly with its nationwide Information Society Strategy, and focusing on developing teachers' knowledge and skills that are needed to *reform* pedagogical practices, "especially with regard to collaborative teaching and learning, networking, and team work" (Kankaanranta and Linnakyla, 2003). The Strategy anticipates that "the Information Society, the genesis of a digital and global economy, and the development of the media require substantial changes to the culture of work and professional competence", and that professional development for teachers is organized within this broader context.

The policy-level developments described above echo much of what is found in the research literature: that ICT-related professional development must help teachers to adapt to new and changing roles (Scrimshaw, 1997), and that teachers can learn about the use of technological tools in the context of changing pedagogical approaches, such as the use of computer-mediated collaborative environments to support project-based learning and inquiry-based learning (Kozma and Schank, 1998). McDougall and Squires (1997) also identified a similar list for organizing training for teachers, which includes teachers' ability to integrate the use of ICT into existing curricula, making ICT-related changes in curricula, and underpinning theories of education.

Given the general recognition of the importance for ICT-related teacher professional development to focus on the pedagogical approaches and pedagogical use of ICT that will support changes in the roles of teachers and learners, the findings of the SITES-M1 survey concerning the availability of different kinds of courses are noteworthy

and should be a cause for concern for policy-makers at various levels of the education system. Pelgrum and Anderson (1999) found that in most countries, the technology co-ordinators surveyed reported a general availability of basic technical skills courses and a serious lack of courses related to pedagogical/didactical principles of ICT use. The CompEd Study, conducted in 1989 and 1991, already reported this problem. How to make the best use of ICT to support and extend learning is undoubtedly the most challenging aspect of professional development which, as will be argued later, requires forms of staff development beyond that of traditional course attendance.

Professional development for school principals

Principals take charge of resource deployment, staffing and personnel matters in schools, and should also play an important leadership role in the school curriculum. In a study of 18 schools that had made a head start in introducing ICT across the curriculum in Hong Kong, it was found that the way in which ICT was used, and its impact on learning and teaching, bore no relationship with the technology infrastructure or technical skills level of the teachers. Instead, it was very much determined by the vision and understanding of the school principal and the prevalent school culture (Law *et al.*, 2000; Yuen, Law and Wong, 2003). Leading change in the information age is thus a challenge that school principals face and for which they need professional development support. This aspect of professional development has not been so well documented or explored as teacher professional development, and perhaps has not received due attention.

Only in a few countries such as Cyprus, Germany, Singapore and New Zealand were special arrangements made to cater for the professional development needs of principals. In Singapore, principals were among the first to undergo professional development, and their role in leading the change process was clearly articulated within the professional development programmes. New Zealand organized, at an early stage of its ICT implementation across the curriculum, a series of seminars titled 'Principals first', which provided principals with a planning and implementation guide to provide practical advice on the purchase and maintenance of ICT for teaching, learning and school administration.

ICT co-ordinators and support for teachers

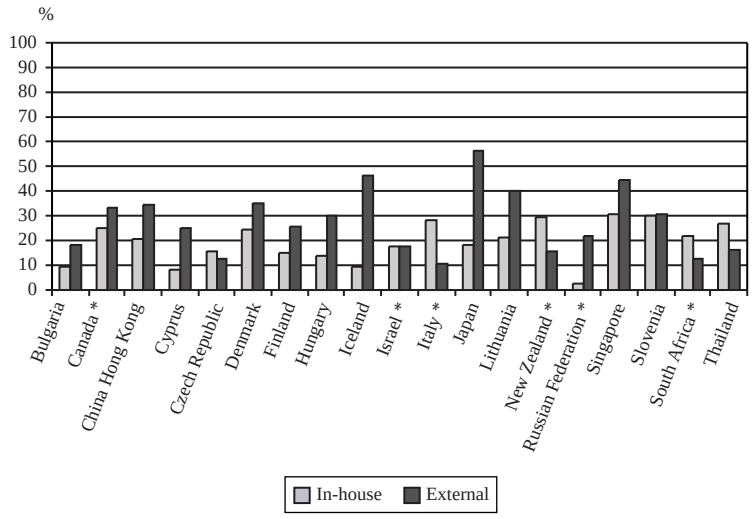
ICT co-ordinators play an important role in the process of implementing ICT in schools. Some education systems, for example in Japan and Hong Kong, have recognized the special role of ICT co-ordinators in schools and provide training for those occupying such positions. In other systems, there may not be formal appointments of ICT co-ordinators in schools, and normally the more ICT-competent teachers would assume such roles in their schools. Technology co-ordinators may play a variety of roles in schools, which may fall under three broad categories: providing technical support for hardware/software purchases, installation and maintenance; organizing and conducting staff development programmes; and developing the ICT implementation plans in their schools. The SITES-M1 study found that most of the technology co-ordinators in the 26 systems surveyed considered their ICT knowledge to be mostly adequate, while they were generally much less confident about their own knowledge regarding the pedagogical use of ICT for giving support to teachers in the school. This implies that most ICT co-ordinators are not well prepared for two of the three roles that they may play in schools. They need to learn about the uses of ICT that can support curriculum and pedagogical innovation, and to be aware of the role change demanded of teachers in the process. Furthermore, ICT co-ordinators often play the role of change agents in the ICT implementation process. They thus need to learn about leadership and mechanisms for managing change in order to foster and support school-based curriculum innovations that integrate the use of ICT. As will be argued in the next chapter, technology co-ordination and support are strategic elements in ICT implementation in schools.

Obstacles associated with staff development

The SITES-M1 cross-national survey (Pelgrum and Anderson, 1999) reported that both principals and technology co-ordinators perceived teachers' lack of knowledge to be the second most serious obstacle in implementing ICT in the curriculum (see *Table 3.2*). This is a long-standing problem that has existed since the first major efforts were made to introduce ICT in education (Pelgrum *et al.*, 1993).

Why has staff development been such a persistent problem? One potential reason might be that there are not enough courses available for teacher training. *Figure 4.1* seems to indicate that the availability of courses as perceived by school technology co-ordinators was indeed quite low.

Figure 4.1 Percentage (averaged across a list of 12 types of courses) of internal and external courses



* Country did not satisfy all sampling criteria.
Source: Adapted from Pelgrum, 1999*b*.

However, for a schoolteacher to be able to use ICT effectively in teaching, the challenge consists of much more than acquiring technical know-how, which is merely the first hurdle. It often also happens that some students are more IT-literate than their teachers, and some teachers may see this as a challenge to their traditional role of being the more knowledgeable expert in the classroom. Teachers' inadequate English language competence has also been reported as an obstacle to teachers' learning of ICT (Grinfelds, 1999).

Motivating teachers to undertake ICT-related professional development is another issue that policy-makers need to take into consideration. While there have not been clear indications that a lack of teacher interest was a major obstacle, this problem was considered a major one in a few countries such as Luxembourg, South Africa, the Czech Republic and Lithuania, where it was reported by more than 40 per cent of the principals.

It is noteworthy that in most countries, the percentage of principals reporting that a substantial number of teachers in their schools had taken basic ICT courses was far greater in schools where taking such courses was not obligatory than in those where it was obligatory. This situation was reversed in a small number of countries such as Bulgaria, Chinese Taipei and the Russian Federation (Pelgrum and Anderson, 1999). In some cases, teachers were provided with monetary incentives for the completion of training courses (e.g. about 25 per cent of principals in Lithuania reported making such provisions). However, the monetary reward from within the education sector, even if available, is often not sufficient to persuade teachers with specialist ICT skills to stay in schools. This 'drain' of trained teachers as they move to more highly-paid IT-related jobs is reported in both developed and developing countries (Banfi, 1999; Becta, 2001).

It has also been found in some national evaluation programmes (e.g. Becta, 2001) that even in instances where teachers are trained and where the infrastructure is available, teachers do not have the confidence to use ICT in the classroom. Studies conducted in the USA, the United Kingdom and Australia have revealed that computer anxiety and lack of confidence are important factors that hinder teachers' willingness and effectiveness in using computers in the classroom (Rosen and Maguire, 1995; Russell and Bradley, 1997).

Another major obstacle in the area of staff development is the rapid changes in technology, which make continuing professional development provisions almost mandatory, thus putting enormous strains on implementation. For example, the South Korean Government had a plan in place to provide training to 25 per cent of all teachers each year. However, even a plan of this magnitude would

require a four-year retraining cycle, which was considered inadequate for keeping teachers abreast of technological change (Korean Ministry of Education, 2000).

Getting teachers to start using ICT in the classroom may be a first hurdle at the beginning stage of ICT implementation across the curriculum. Research findings show that teachers who use ICT in ways that add value to the teaching and learning process, such as to increase students' motivation or to stimulate higher-order thinking, are relatively rare (e.g. Becta, 2001). In a set of case studies conducted on classroom practices using ICT on a group of schools in Hong Kong which were making pioneering efforts in ICT implementation, it was observed that most teachers used technology to do electronic presentations for expository modes of teaching, without any change in their pedagogical paradigm. Staff development that focuses specifically on helping teachers and other education practitioners to understand the curricular and pedagogical potential of ICT, and the need to bring about changes in the goals of education demanded by the information age, is crucial to the realization of many national ICT-in-education masterplans. This will be elaborated in *Chapter 6*.

In summary, it appears from empirical data that it is a lack of training opportunities for teachers, rather than a lack of awareness at the leadership level of schools or a lack of interest from teachers, that presents a major obstacle. Carlson and Gadio (2002) argued that while teacher professional development is "woefully underfunded" generally, the situation of training in the use of technology is much worse, as policy-makers operating within budget constraints tend to give priority to hardware and software acquisitions. It is not easy to attract funding priority to teacher professional development, not only because it does not produce immediately visible 'results' such as with computer:student ratios, but also because it is "costly, time-consuming, pedagogically and logistically challenging, and often results in difficult-to-measure outcomes" (Carlson and Gadio, 2002). Thus, while it is important to improve the availability/accessibility of training courses for teachers and other education professionals, other issues, such as the aims, content and modes of delivery, also need to be considered.

Forms of staff development provisions

Teacher education, and in particular initial teacher education, needs to undergo changes to prepare new teachers for the challenges of the information age. Many policy-makers, for example those in the APEC region, have made explicit calls for pre-service curricula to put a stronger focus on "pedagogy, application of theory and skills development rather than strictly content knowledge"[9]. Some countries have also set up research programmes in their schools to develop innovative experimental teacher education programmes that integrate the development of theoretical knowledge with classroom practices in schools, through promoting student teachers' reflection on their attitudes towards and beliefs about teaching, learning and the teachers' role (Willis, 2001). Some experimental programmes were conducted in partnership with schools as joint explorations, and these contributed simultaneously to the continuing professional development of teachers in the partnership schools (Hill, 1997). In the Netherlands, as part of the National ICT in Education Masterplan, two teacher education institutions have been designated as experimental institutions for utilizing ICT in innovative ways in teacher education, and further funding was made available for teacher education institutions to carry out similar innovation projects with ICT (Doornekamp, 1999).

In terms of continuing professional development for in-service teachers, staff development programmes may take the form of seminars, short courses, extended courses and on-line distance learning modes. These may be provided by external agents or organized as school-based offerings. Diverse modes of staff development are typically found in many countries to meet the diversity of needs. The SITES-M1 study conducted in 1998 in 26 education systems (Pelgrum, 1999*b*) found that the four most popular means of staff development in schools were attending external courses, attending in-school courses, learning via the technology co-ordinator, and learning via teachers who replicated the delivery of external courses that they themselves had attended. It was also found that in general, there were more external

9. Improving Teaching Systems, a main paper for the 2nd APEC Education Ministerial Meeting 'Education for learning societies in the twenty-first century', 7 April 2000. http://aemm.moe.edu.sg/asp/asp_aemmpaper/aemmpaper.asp

than in-house courses (*Figure 4.1*), and that most of the in-house training was related to basic computer-handling skills and the use of basic applications. Further, only very few respondents commented on the availability of external courses that dealt with didactical/ pedagogical principles of computer use or with subject-specific training. It is thus not surprising to note that the technology co-ordinators participating as respondents in this survey reported much lower self-rating in terms of the adequacy of their own preparation for instructional use of ICT.

As mentioned in an earlier section, teachers often experience anxiety in using ICT in classroom settings, even after they have attained the requisite levels of competence. A study conducted of government schoolteachers in Queensland, Australia, reported that access to computers at home and at school, and opportunities to observe skilled colleagues working with computers, were considered the most important ways to increase teacher confidence and competence (Russell and Bradley, 1997). Some teachers wanted to have opportunities to 'muck around' with computers and to not have to worry about being labelled as computer illiterate or causing damage to computers. The recognition of the need for teachers to have ready access to computers for developing computer literacy and competence has led to the creation of national schemes to provide teachers with notebook computers as part of national ICT-in-education implementation strategies (for example in the UK and Singapore). In a study of good practices in the use of ICT in classrooms in Hong Kong, Law *et al.* (2000) also reported that school-based efforts to provide notebook computers to teachers were effective in promoting classroom use of computers.

With the widespread use of school-based modes of staff development, the 'training of trainers' has been reported to be a common and cost-effective model of teacher training (Blurton, 2000), where a small group of 'teacher-leaders' are selected to receive intensive training courses before returning to their own educational institutions to provide ICT-related training to their peers. However, cascade models of staff development would be more effective if coupled with increased collaborative support from teachers within the same school. It is thus noteworthy that although a variety of mechanisms for knowledge transfer are available in many systems,

research findings seem to indicate that informal contact and communication is the most prevalent form of transferring ICT knowledge (Pelgrum, 1999*b*). However, Russell and Bradley (1997) also reported that teachers may not be willing to 'take advantage' of support from other, more knowledgeable colleagues unless such contributions could be formally recognized by the school authority. School-based staff development provisions therefore must be planned as part of a coherent human resource and staff appraisal/reward package. It has to be planned as a strategic component in conjunction with curriculum development and implementation to achieve the priority goals for the school.

Models of staff development in the information society

While teacher training courses have focused largely on the development of ICT skills, many studies across different countries have consistently shown that such approaches to staff development were ineffective in building up teachers' capacities to integrate the use of ICT into the curriculum (Plomp, ten Brummelhuis and Rapmund, 1996; Williams, Coles, Wilson, Richardson and Tuson, 2000; Vrasidas and McIsaac, 2000; Lang, 2000). The fact that technology is changing so quickly that it is hardly possible to keep up to date makes current forms of delivery-centred staff development even more inadequate. Therefore a new paradigm for staff development is needed. Many studies have pointed to the importance of staff development programmes in which models of ICT use and integration can be developed and which can be linked to change and innovation at the classroom and institutional levels (e.g. Anderson, 1996; Somekh and Davis, 1997; Potter and Mellar, 2000). The findings from such studies suggest that in-service staff development is most effective when delivered in connection with a school development plan.

The increasing demand for ICT to play a critical role in bringing about fundamental changes in educational goals and in the roles of teachers is accompanied by increasing efforts in some countries to support the establishment of teacher communities as communities of practice (Wenger, 2000) in order to foster the development of the new learning culture desired. The APEC Education Ministers' survey of member economies reported a great interest in participatory

approaches to professional development. Here teachers would be involved in initiating and designing their own professional development and would share materials and ideas as well as discuss challenges and solutions. This approach towards professional development would also help teachers to become models of lifelong learners. There have also been efforts to build new environments, such as TAPPEDIN[10], to promote and support the establishment of on-line communities of teachers and to provide support in professional development across a range of subject areas and themes.

The SITES-M2 case studies provide additional insight into effective staff development. In many of the innovations studied, teachers acted as self-directed, autonomous learners, who identified and met their own learning needs during the process of exploration and creation of the new pedagogical practices. These teachers were frequently involved in student projects as participators, contributing to the solution of problems and taking part in the learning process. Quite often these teachers literally said: "We learned a lot about ICT and about new pedagogy by doing this project". A further feature of these case studies was that many of them involved new learning arrangements requiring collegial collaboration among teachers, resulting in the exchange of, and improvements in, teachers' expertise. These observations can be taken as the starting point for initiating forms of future staff development linked to school-based curriculum innovation, a model of learning by doing.

Many of the SITES-M2 case studies of 'emerging pedagogy' for the Information Society were found in 'normal' schools that were resourced not very differently from other schools generally found in those countries. This indicates that many of the related policies on implementing ICT for curriculum change and innovation are practicable. However, it was also apparent that the practices in these case studies were far from being daily practices in most schools. To sustain, transfer, and further develop these innovative practices requires two conditions. The first is a heavy dependency on the provision of teacher professional development opportunities. The second, which

10. http://www.tappedin.org

is of even greater importance, is the development of emerging goals and models of teacher education that will foster the establishment of learning communities of teachers that will, in turn, generate, refine, consolidate, and disseminate emerging pedagogies and emerging professional competences.

Resourcing for staff development

As the scale of ICT-related staff development has to be very large in order to cater to the needs of the entire teaching profession, and since it has to be a continuing process, resourcing is an important issue. Generally, this has been accomplished through the combined efforts of the central government, the local education authorities and school-level inputs.

In the previous sections we have argued on several occasions that politicians and education practitioners seem to be willing to move towards more student-directed modes of education. This implies a change in teachers' roles to include less lecturing and more counselling, supervising and guiding. Consequently, teachers need to continuously update their knowledge and skills in the subject area they teach and find meaningful ways of using ICT for teaching and learning in the subject area. This kind of continuous staff development provision would, if organized in the traditional way, require enormous budgets, which would be beyond the capacity of even the most economically developed countries. Therefore one may argue that self-initiated, autonomous, lifelong learning would be an important component in any national strategy on teacher professional development. In fact, this mode of learning is to be expected of every future citizen as part of his or her own involvement in personal and career development. This, for instance, would imply that schools may not necessarily send their teachers to attend external courses, but rather that teachers themselves initiate activities to develop skills that are needed for implementing the strategic educational plans of the whole school. Teacher educators could provide guidance and counselling through physical or virtual presence. The extent to which teachers contribute to the strategic planning and staff development of their own schools might be additionally rewarded as one important dimension in staff appraisal and promotion.

Continuous staff development should be financed as an integral component in any education budget to ensure that schools have the capacity to undertake continuous improvement and curriculum renewal, and as such may be financed nationally or locally. However, kick-starting a nationwide implementation of ICT across the curriculum often requires national-level financing to ensure that some baseline teacher competences can be built up reasonably quickly so that a more pervasive implementation plan can be effected. It has been observed that the priority given to staff development as a strategic implementation strategy varies greatly in terms of the proportion of resources allocated and how this aspect is scheduled in relation to the other elements in a system's implementation strategy. Hong Kong and New Zealand are examples that aptly illustrate the diversities existing in this area. In Hong Kong, out of a total of 3.05 billion Hong Kong dollars (about 391 million US dollars) earmarked for a non-recurrent grant for the five-year IT in Education Strategic Plan, only 16 per cent was allocated to staff development. The rest of the funding was devoted to setting up an ICT infrastructure in schools. Furthermore, the main staff development initiatives were only started in the second year of the Strategy, when most of the infrastructure had been set up. New Zealand, on the other hand, has consistently made professional development the main focus of government support since 1993. Until 1999, there was no national policy on the acquisition of computer hardware or software. From that point on, a school has only been able to receive funding when it produces a strategic plan that meets a range of criteria established by the government and the Ministry of Education.

Future developments in the resourcing of staff development probably need to be seen within the context of teachers' self-responsibility for lifelong learning at the individual level, in combination with the facilitation and support from school organizations and the government.

V. Organizational change and leadership

The potential benefits, implications and challenges of introducing ICT into schools can be very different depending on the vision and understanding of the nature of this change, as well as strategies for its management adopted by the leadership at the school level and beyond. This chapter reviews the key issues and experiences that are important for leading schools to become learning organizations of the twenty-first century in the process of ICT implementation.

The challenge of integrating ICT for educational institutions

This chapter focuses on issues related to organizational change and management for technology integration in teaching and learning in educational institutions. Leading educational institutions into the information age is a challenge for many who occupy positions of responsibility at various levels of the education system. As Ringle and Updegrove (1998) pointed out, there are two key dimensions to the planning of such changes. One is socio-economic, and the other is pragmatic/technical. Often, planning for implementation starts with and focuses on the latter, while socio-economic considerations are more crucial and should provide the vision and context for the entire process. Studies in the management of change and innovation have shown that the process of change is a complex one, involving not only changes in infrastructure and curriculum materials, but more importantly of practices and beliefs (Fullan, 2001; 1993).

As is true of any change that would involve important impacts on educational practice, the change has to align with other institutional priorities if it is to be successful. However, case studies of ICT implementation in schools in a number of countries have indicated that the vision and goal of the implementation can be very different, even for schools that have been actively engaged in the innovation

(Law *et al.*, 2000; Lankshear *et al.*, 2000; Mooij and Smeets, 2001). It might be expected that implementations where the change does not pose challenges for existing educational priorities or beliefs of the school would be relatively easy to implement. However, the case studies mentioned above indicated that where the implementation did not perceive the change to relate to the wider socio-economic context and the potential contributions of ICT to the community and the school, such implementations may not be successful, even at a mechanical level of adoption or in maintaining sustainability. The complexity of the change process arises from the fact that classrooms are intrinsically complex, self-organizing systems, and attempts to manage change in simplistic ways would simply be inadequate:

> "Classrooms are complex, self-organizing, adaptive systems: they have to arrange themselves around the interactions between their various human and non-human components. Each time a new component – such as a new technology or a new policy – is added, it does not feed one more 'thing' into the mix in a linear way: rather, its introduction produces a compound effect. The new component rearranges all the other interactions, and may add many more in its own right. Classroom practices then have to reorganize themselves around this new complexity, which involves changes in roles, changes in relationships, changes in patterns of work and changes in allocations of space in the classroom" (Lankshear *et al.*, 2000: 112).

The challenge that ICT integration poses for educational institutions thus depends on both the vision and the values embodied in the change, as well as the existing culture and values of the institutions concerned.

Organizational change and leadership for ICT integration

It is easily recognizable that the following factors are essential in any strategy to integrate ICT into the teaching and learning process: provision of access to computers; network and Internet access; training of teachers; provision of ICT-based curriculum resources; and technical

support. Many national or school-based implementation plans are in fact plans for provisions in these areas. However, these factors alone, though essential, would not be sufficient to bring about the kind of organizational change that would be necessary. Leadership involves the acquisition and orchestration of these factors within the contexts and constraints of the organization in defining and achieving the desired outcomes. To provide a better understanding of the issues involved in leading change, it would be instructive to examine some case studies conducted of schools and classrooms that have undertaken such implementation.

Lankshear *et al.* (2000) reported on the findings of a number of case studies on the use of technology in literacy education in Australian schools. The study highlighted several noteworthy observations, which illustrates demonstrably the need for a system approach to change and innovation in order to achieve sustainable implementation and success. One key observation was the apparent unevenness and tension in some critical aspects during the course of development. There was tension between the available computing infrastructure and aspiration of the school on the one hand, and the availability of crucial infrastructure beyond the school, such as the telecommunication capacity in the geographical area where the school was located, on the other hand. These factors were constraining the capacity of the school to undertake classroom practices involving access to the Internet. Another tension was the unevenness in the distribution of resources and expertise within or across schools; for example, the concentration of technical expertise in one or two staff members in a school made the innovation very vulnerable as the departure of a key member of staff would bring it to a halt. Lankshear *et al.* (2000) also observed that such tension and unevenness led to discontinuities through different school years and/or across school subjects resulting from the isolated implementation of ICT in classrooms. The introduction of new technologies may be perceived as a challenge to the established authority and expertise of parents and teachers and caused doubts and suspicions of these groups of stakeholders in the education process. The use of technology introduces a new literacy that emphasizes different skills and competences and competes with existing priorities and values, which brings about a feeling of resentment among some teachers.

In examining the models of ICT implementation in a number of Hong Kong schools that were enthusiastic and successful in adopting ICT in the teaching and learning process, Yuen (2000) categorized the schools into three models of technology integration according to some critical characteristics exhibited in the adoption process: the technological adoption model, the catalytic integration model, and the cultural integration model. Most of the schools in the study possessed characteristics that were labelled as 'technological adoption': the principal and most teachers perceive the purpose of using ICT to be one of enhancing current teaching practice, and the key obstacles were perceived to be the acquisition of adequate technology infrastructure, technological skills (by teachers and students) and ICT-mediated curriculum resource materials. These schools generally went about planning for ICT implementation with clearly defined targets and schedules, and the school principal was often the main change agent. While the change processes were often orderly and well planned, the impact of 'technological adoption' on the modes of teaching practice and learning outcomes in these schools was found to be minimal. The use of technology was mainly confined to multimedia presentations in support of expository teaching.

The 'catalytic integration model' was characteristically adopted by schools with visionary leadership and which had been on a track of educational reform geared towards more student-centred, empowering pedagogies. The principals in these schools were consciously perceiving the introduction of ICT as an opportunity for furthering and deepening the reform process. The main focus of the implementation plan was on teacher professional development, with a strong emphasis on curriculum leadership and development. The ICT-using teaching practices found in these schools were often more student-centred, involving more innovative pedagogies such as social constructivist collaborative project-based learning and problem-based learning tasks. Thus it was found that the integration of ICT in these schools in fact helped to advance the curriculum reform initiatives already under way.

The 'cultural integration model' (Law, 2000*a*) was used to describe the model of technology implementation found in schools that were known for having a distinctive school culture that focused

on student empowerment. These schools had already established practices and structures to support student-initiated projects and activities, and the established school ethos was to support the development of self-actualization and the lifelong learning abilities of students. The introduction of ICT into these schools was perceived mainly as an opportunity to provide a very powerful and versatile tool for the empowerment of teachers and students alike. These schools had a deeply rooted culture of respecting the choices of individual teachers and students, and there was no coercion to learn to use technology. However, the school leadership would encourage the adoption of technology through the channels already established in the school for curriculum leadership and staff development. The schools in this category exhibited the widest range of pedagogical approaches in the use of ICT found in this study, including expository and social constructivist approaches as well as the use of ICT as a cognitive tool in the teaching and learning processes.

These two sets of case studies described at some length above, demonstrate the complexity of the change process, which is dependent on the history and culture of the school, as well as the need for school-level implementation to be well co-ordinated with the policies and implementation strategies at the system/national level.

Changing teaching and school culture – schools as learning organizations

Fullan (1999), in reviewing many failed reform efforts in education, concluded that the hardest problem is to bring about changes in instructional practices and to establish a culture of collaborative relationships among students, teachers and other potential partners. Simply changing formal structures would not lead to fundamental changes unless norms, habits, skills and beliefs were brought into focus and modified. Schools would not be able to bring about the kind of development desired of students as implied by the lifelong learning rhetoric – i.e. having a sense of purpose, habits and skills of inquiry and the ability to work with others and to cope with change – if their teachers did not have any experience of similar developments themselves (Sarason, 1990). On the other hand, it has been well

documented in the literature on educational change that teachers generally work in 'autonomous isolation' (e.g. Fullan, 1991; Goodlad, 1984) and that this is not conducive to the development of a collaborative culture for mutual assistance and school improvement. In fact, for schools to become effective nurturing grounds for lifelong learning skills, they have to become learning organizations. These are institutions whose members anticipate and are ready to engage in continuous efforts to collaborate in learning about new problems and developing solutions to face new challenges.

Senge (2000) highlighted five principles that are crucial if schools are to become learning organizations. These principles are described below with some brief interpretation as to how they may apply to technology-supported education reforms:

- Personal mastery: everyone in the institution, children and adults alike, should develop a personal vision and aspiration, and an awareness of current realities. As in any change process, the integration of ICT brings with it both opportunities and risks. The institution should encourage each of its members to develop a sense of mastery with respect to the anticipated changes, so that the institution and its members may engage in an expanding and deepening vision.
- Mental models: individuals have mental models which are often different, influencing their perception and interpretation of the world around them, and limiting their ability to change and act together. Conscious, shared efforts to reflect on and inquire openly about models, and assumptions on the goals, conditions for success and strategies for ICT implementation, are critical as such engagements will draw forth abilities greater than the sum of the individuals' talents.
- Shared vision: for changes to be institutionally sustainable, the process of bringing disparate, individual aspirations into alignment around the things people have in common is critical in building a sense of commitment to a future to be created collectively. Planning for ICT implementation must be accompanied by a process of vision building so that all stakeholders involved in the process can engage in sharing individual understanding and

aspirations and seek to establish a common goal. Vision based on authority will not be sustainable.

- Team learning: teachers and students need to work in teams in order to realize the collective vision. This cannot be achieved by team-building exercises, but by the establishment of various work teams: the ICT co-ordination team, the staff development team and/or curriculum innovation teams, as the case may be. It is through sustained collective inquiry into everyday experiences and assumptions of these work teams that a collective sensitivity can be developed, whereby the thoughts, emotions and resulting actions belong not to one individual, but to the team.
- Systems thinking: the discipline of looking at problems and goals not as isolated events, but as components of larger structures. Leadership should not rush into rapid crisis management. What may appear to be the key obstacles, such as lack of technical competence of staff or staff reluctance to change, may not be resolvable by tackling them directly. Leadership needs to look for interdependence and change, feedback and complexity so as to find ways of moving the institution forward.

Thus, it is expected that the implementation of ICT for teaching and learning would require organizational changes in structure so that the necessary physical infrastructure could be set up and maintained, and to organize the necessary staff technological development in the school. However, such organizational changes are not the most important or critical factors for success. The much deeper change described above can only take place if it is led by a dynamic and visionary leadership capable of developing and implementing a collective plan to bring about changes in organization culture, beliefs and practices.

Technology co-ordination and support as strategic elements in change leadership

Implementation strategies need to be planned and executed through the establishment of suitable organizational structures. This is especially true of change involving technology. At the school level, all schools that use technology would have some personnel responsible

for the co-ordination of technology. However, the composition, role and function of such personnel may differ. In their case studies of ICT implementation at the school level, Law *et al.* (2000) found that nearly all the schools studied had established an IT co-ordination team consisting of more than one member. Some schools, especially those exhibiting characteristics of 'technological adoption', perceived the main functions of the IT co-ordination team to be technical and technological, and included as its roles the setting up of the school technology infrastructure, the co-ordination/provision of technical support and staff training. The membership of the IT co-ordination teams in these cases mainly comprised teachers with a strong technical background. On the other hand, schools characterized as adopting the 'catalytic integration model' or the 'cultural integration model' perceived curriculum leadership and supporting teacher professional development to be the keys to successful implementation. These schools normally have a much broader membership for the IT co-ordination team, including staff having key roles in the determination and development of the school-based curriculum and teacher professional development plans.

The desirability for the technology co-ordination to be undertaken by a team with membership comprising a broad spectrum of expertise and responsibility, is reinforced by Lankshear *et al.*'s (2000) report on a successful case of implementation leading to deep changes in teaching practice, where the head of computing, the head of IT and the curriculum co-ordinator formed a team to implement change. The team then identified key persons in each subject area, and worked with these individuals to initiate change and development in the various curriculum areas. It is to be expected that the effectiveness of a technology co-ordination team also depends very much on the recognition and support given by the school leadership. However, the role expected of the technology co-ordination team and the status and reward given to technology co-ordinators seem to vary greatly, even across schools within the same system, reflecting very different perceptions and management practices of principals (Law *et al.*, 2001).

In addition to the provision of technology co-ordination and appropriate staff development opportunities, the support available within the school is also very important in enabling teachers to make

effective use of technology in their teaching practices. There are two kinds of school-based support that are needed. Firstly, on-site technical maintenance and support services to teachers and students are crucial to ensure that teachers have confidence in executing curriculum plans that involve the use of ICT. Another, more crucial form of support is in the pedagogical and curriculum areas. It was found that ICT co-ordinators often play the role of planning and co-ordinating for infrastructure development as well as staff development within a school. They may also contribute to the curriculum and the pedagogical change process in a school if the goal of implementation is envisioned to be an opportunity to lead to 'emergent practices' and the establishment of an 'emergent paradigm' in the school (Pelgrum and Anderson, 1999). The SITES-M1 study found that in many countries, the most prevalent arrangement for the transfer of ICT-related knowledge within schools is through the ICT co-ordinator. Providing mechanisms for information and expertise on new ICT-using approaches to teaching and learning so that these can be shared among teachers in the schools is thus a key strategy for leading ICT integration.

As mentioned earlier, settings whereby teachers work in isolation are not conducive to the development of a collaborative culture for mutual assistance and school improvement. Organizational encouragement and support for the establishment of communities of practice for teachers within and beyond the school would be important factors to support change. This can be achieved at the school level through the ICT co-ordination team as well as other school-level organizations. Various teacher professional organizations and other educational organizations may also play an important role in supporting professional development and change at regional, national and international levels through the provision of channels for experience and resource sharing.

Instituting sustainable change and innovation: care for old and courage for new

The remainder of this chapter examines some specific critical issues and strategies for implementing ICT in school education. To

summarize the discussion so far, successful implementation will require fundamental changes in the following key aspects:

1. Teaching and learning need to shift their focus:
   - from content to process;
   - from cognitive development to metacognitive and affective development;
   - from learning as an individual enterprise to learning as a collaborative endeavour;
   - from learning as reproduction of what has already been known to production of new understandings and solutions.

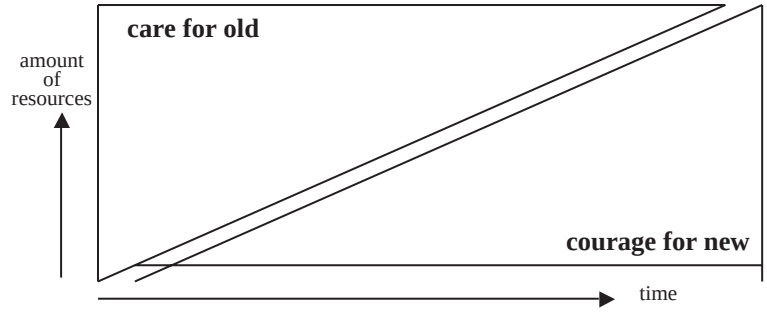
2. The roles of teachers and learners need to change:
   - from teachers as the authority and custodian of knowledge to facilitators and co-learners;
   - from learners as passive recipients of defined knowledge and skills to knowledge workers actively engaged in learning about and solving personally meaningful problems.

3. The nature of schools needs to change:
   - from being providers of well-defined educational services to becoming learning organizations engaged in preparing children and youth for life in the twenty-first century.

Given the complexity of the change to be instituted, the question of how to ensure that the change is effective (rather than expedient) and sustainable (rather than transient) is crucial. As Heppell (2000) pointed out, "with new technologies, between denial and adoption is the space for innovation and that is where radical progress is made". One important feature of innovation is that while the intended direction of change is known, the exact form of the practices has to be evolved and the driving forces for such practices to emerge is not yet fully understood. It is in this context that the SITES-M1 study broadly categorized ICT-using classroom practices into 'emergent' and 'traditionally important' ones (Pelgrum and Anderson, 1999). Furthermore, for the emergent practices to replace existing ones, care and respect must be given to existing practices and organizations. The change has to be gradual. As Plomp *et al.* (1996) pointed out, "To initiate an emergent practice it takes creativity, to maintain its

development and bring the experiences to useful results it takes endurance, but to keep up the intention of replacing existing practices it takes courage". The same document provides a very helpful figure for the conceptualization of the change process (*Figure 5.1*), highlighting the need for the change programme to not be exclusively aimed at realizing the future, but also to take care of the existing practice.

Figure 5.1 'New' replaces 'old'



Source: Plomp, ten Brummelhuis and Rapmund, 1996: 32.

Using this framework, the implementation of ICT in schools will need to bring in new practices and new forms of professional support and education so that ICT can be used to support traditionally important teaching practices ('care for old') as well as the development of emergent teaching practices ('courage for new') (Plomp *et al.*, 1996). Implementation strategies to encourage the use of ICT in traditionally important teaching practices (as 'care') would include:

- the provision of training on baseline technology skills for teachers and students;
- the provision of a good technology infrastructure, including computer access and network connectivity, to teachers and students;

- challenging the teacher education institutions to systematically integrate ICT into the teacher education programmes, as well as to become actively involved in supporting the change process; and
- the establishment of centres for learning technology in teacher education institutions to support the systematic integration of ICT for educational purposes within these institutions as well as in the schools affiliated to them.

On the other hand, implementation strategies to support the development and widespread adoption of emergent teaching practices (as 'courage') would include:

- the stimulation, solicitation and funding of project proposals that aim to create examples of desired future arrangements of an education that integrates the use of ICT in ways that would develop students' lifelong learning abilities and move schools in the direction of a learning organization;
- the establishment of experimental teacher education programmes to develop new approaches to teacher education with the aim to transfer knowledge and experiences to regular training programmes; and
- to engage universities and research centres in research integrated with programmes of action on the use of technology in education to develop an adequate knowledge base to guide school efforts.

Partnership and leadership

While leadership is critical to the successful implementation of change, top-down approaches to change would not lead to effective and sustainable changes in teaching practice. There needs to be partnership, or shared participation, in vision building and implementation decisions with staff members within the institution. On the other hand, research also found that a whole-school approach to change involving participatory decision-making does not in itself guarantee success. Fullan (1999) cited a number of studies where high levels of participation in decision-making took place, but which did not lead to changes in teaching strategies or increases in teacher-

teacher collaboration. He concluded that participatory leadership would not lead to changes in teaching practice unless the participatory decision-making was focused on the central issues of curriculum and instruction.

Leadership for change would be greatly facilitated by the establishment of strategic partnership with members outside of the school staff community. Schools and teachers should look for opportunities to join forces with students, parents and other stakeholders, community groups and organizations for physical resources and human resource expertise support as well as moral and political support. It has been observed that some of the schools in the SITES-M2 study have taken advantage of the use of technology to broaden the scope of contact and learning experience of students beyond the classroom walls. Many of these cases have also involved individuals or institutions from the community in various aspects of the curriculum process in some form of partnership arrangement. Partnership would be greatly strengthened if it was coupled with participatory decision-making. This often includes changes in the management structure of schools so as to empower schools and their members. Schools should be given increased autonomy from centralized bureaucracies, and school-level decisions should involve participation from teachers as well as other stakeholders, such as parent associations and student representatives. Schools could also establish regional or international partnerships with other schools and communities through some established international networks such as the iEARN[11], Thinkquest[12] and WorldLinks.[13] A system approach to change leadership (as illustrated in *Figure 1.1*) should involve the participation of different partners that are variously involved with education in schools.

11. http://www.iearn.org
12. http://www.thinkquest.org
13. http://www.world-links.org

VI. National educational policy and implementation strategies in ICT

National policies and implementation strategies on ICT in education differ between countries depending on the national priorities, economic and cultural contexts, as well as the wider educational systemic context and changes currently in place in the respective countries. This chapter describes the variety of policy goals and implementation strategies adopted by different countries, highlighting the contextual factors, and also discusses their impacts and implications.

Varieties of policy goals

While ICT started being used in education over more than two decades ago, the establishment of explicit comprehensive national or regional educational policies and implementation strategies for ICT in education is a relatively recent phenomenon. While some developed countries may have developed IT masterplans that encompassed educational components about a decade ago or more, most IT-in-education masterplans emerged within the past few years. In fact, a World Bank report (Bank, 1998) pointed out that "many governments stand at the threshold of the twenty-first century without clearly defined plans and strategies about the use of educational technology". No country can afford to ignore the need to introduce ICT into the education system. However, as the report pointed out, many countries are investing heavily in this area without having clear plans and objectives. This chapter reviews the variety of goals and strategies, as well as their impacts on development in different countries, as a reference to those who are interested or involved in strategic planning in education.

It is predictable, and clearly observable, that national priorities and strategies for ICT implementation in education differ widely from system to system. It is, however, noteworthy that, though there are

wide variations in terms of the structure of the education systems and other economic and social contexts, there are also strong similarities in the pathways of change in terms of the goals for introducing ICT into the school curriculum. Generally, the introduction of ICT into the curriculum would go through different phases, typically starting with teaching *about* computers, then moving towards teaching *with* computers, and many countries now aim to integrate the use of ICT in teaching and learning *for educational innovation*. The key differences across countries often lie in the current state of implementation and the implementation strategies used. It is possible that the similarities in the pathways of change could be attributable to the increasing globalization, making the perceived economic impact and imperatives of ICT developments much more internationally aligned than the socio-political realities.

Training IT professionals

The earliest co-ordinated efforts to introduce ICT into the curriculum at the school level started around the early 1980s. As revealed by the First CompEd Study (Pelgrum and Plomp, 1993), the most prevalent use was in the form of studies *about* computers and computing, that is, the computer was used as an 'object' of study (Plomp *et al.*, 1996). Computing, and especially programming, was the earliest form of this type of course to be introduced into the school curriculum (either as an independent subject or as part of an existing school subject, e.g. mathematics), often on the grounds that this would help students to develop problem-solving abilities through programming. The perceived need to meet the demands for IT professionals in the workforce was, in some cases, initially met through the introduction of IT subjects into the senior levels of the school system. This is no longer an important goal in ICT-in-education masterplans, though the learning of informatics still dominates the actual use of IT in the school curriculum in some relatively weak economies, such as those of the Slovak Republic and Malaysia.

Delivering an IT-literate workforce for national development

As the use of computers began to permeate all facets of life – work, leisure and business – there emerged a need to produce a

general workforce that is literate in basic IT competences. The curriculum focus was not on in-depth technological skills and capabilities, but on general IT literacy as basic productivity skills. Starting from the early 1990s, some countries began to introduce computer literacy-oriented curricula at the primary level. However, at this level, computer literacy skills are generally not taught as a separate subject, but integrated into the general school curriculum. This goal is still very prominent in many education masterplans. For example, the recently released South Korean ICT in Education Masterplan declared, "the Korean Government will establish a comprehensive and nationwide information and communication infrastructure to reinforce ICT in education and help grow the information and communication industry. The government will also provide additional resources for educational policy to enhance the people's information literacy in a bold vision to make the nation the most computer-literate in the world by 2002" (Korean Ministry of Education, 2000).

One of the challenges of integrating IT literacy into the curriculum is the training of teachers. While the introduction of computing subjects as new areas of study requires each school to have a few teachers with specialized knowledge and skills, the integration of IT literacy puts demand on a far greater number of teachers, including teachers from non-technical backgrounds. This is particularly challenging at the primary-school level.

Enhancing education effectiveness

Explorations on how computers can be used to enhance education effectiveness began as early as the 1950s in university computer departments. Most of the explorations before the 1980s were concentrated on developing tutorial, drill and practice-type applications. A later foray into such applications took advantage of the greater power of computers to integrate artificial intelligence algorithms with tutorial applications to create systems that can tailor suitable instruction methods for specific learners based on comprehensive models of learner characteristics taken from large numbers of learners. Such applications are generally referred to as intelligent tutoring systems. However, the complexity and challenge of building up adequate systems of this kind turned out to be much greater than initially anticipated. Thus, though

the application of artificial intelligence to education is still an important area of research, this kind of application is rarely found, if at all, in schools.

Since the 1980s, even though the use of information technology for instructional purposes did not have a major impact on the school curriculum, a lot of interesting explorations have already taken place that went beyond the metaphor of computers as tutors. These included using computers as tools and tutees (Taylor, 1980), and the development and use of cognitive tools built on models of learning in specific subject domain areas (Solomon, 1986), which continued to flourish into the 1990s and beyond. Applications within the category of cognitive tools include various kinds of simulation programmes and modelling tools. From the use of computers in the tutee mode evolved conceptions of a new method of learning: a constructionist model (Papert, 1980; 1993) that stressed learning as a productive activity where students learn through active engagement in a creative process.

In conjunction with the increasing interest in using computers to enhance learning, computer-aided learning (CAL) software began to be published to address the needs of this growing education market, and many national ICT policy plans published in recent years include strategies to increase the availability of, and access to, electronic learning resources for schools. Within this context, it is interesting to note that in countries heavily influenced by the Confucian Heritage Culture (CHC) (Biggs, 1996; Watkins and Biggs, 1996), their national ICT implementation has tended to include a new role for 'IT literate' teachers that is not generally found in other countries: that of the teacher as the designer and producer of electronic learning resources. For example in Hong Kong, Chinese Taipei and Mainland China, some of the teacher education courses organized by the government aim to teach teachers to develop multimedia teaching/learning resources and to use authoring tools to develop computer-aided educational software. The introduction of computers into the curriculum to improve educational effectiveness in these systems has led to a predominant use of computers as electronic presentation tools by teachers in whole-class teaching. This seems to be closely related to the importance of teacher-centred instruction and the central role of the textbook in

defining the implemented curriculum in these education systems. The SITES-M1 results also revealed that there was a greater dominance of teacher-centred, traditionally important pedagogical practices in these education systems, as well as a relatively much higher presence of projection facilities, such as LCD projectors, in terms of the ICT infrastructure present in these systems.

With the increasing attention paid to social constructivist models of learning and the advances in computer-mediated communication technologies, there emerged, towards the end of the 1980s, explorations in the use of ICT to support the development of knowledge-building communities – communities of learners who do not simply take in 'knowledge' as created by others, but who engage actively in collaborative meaning-making and the construction of a personal understanding that can be shared with others (Scardamalia and Bereiter, 1991; 1994). This type of work continued to flourish and gained momentum from the mid-1990s as Internet technology became more developed and infused into society at large. Various projects that promote the formation and development of teacher professional development in cyberspace also flourished, e.g. TAPPED-IN, as well as projects that provide learning contexts and supports for students' learning in global collaborative projects (e.g. AT&T learning network, Kids as Global Scientist, etc.). The concepts of knowledge communities and learning organizations have become popular as society moves from the industrial era into the information age. It is also important to note that in these developments, the use of technology is not simply to make learning effective in the traditional sense. These are explorations involving technological innovations to bring about pedagogical changes that would otherwise not be possible. As such, these are innovations that provide a good basis for realizing the more demanding goal of using technology to support educational change and reform that will be discussed in a later section.

Enhancing education access and equity

Another important national educational goal related to the use of ICT that is often pursued is to extend educational provisions and to improve equity in educational opportunities through enhanced distance education provisions. The World Education Forum (2000) listed

'harness new information and communication technologies' as one important strategy to help achieve the Education for All goals. However, the Dakar Framework for Action also cautions that to be effective, the new technologies should serve rather than drive the implementation of education strategies, and that – especially in developing countries – ICT should be combined with more traditional technologies, such as print and broadcast radio, to achieve better effectiveness. This situation is in fact observed in many developing countries. For example in China, where a substantial proportion of the population lives in remote areas of the country, the use of ICT coupled with satellite communications greatly improves the range of educational resources and education opportunities available to people in these areas (Jun, 2001; Liu, 2001). However, distance education offerings in developing countries still use predominantly the more traditional media, such as broadcast radio and television (von Euler and Berg, 1998). Perraton (2002) made a strong case for discriminate use of different technology media for educational delivery, such as radio, television, videoconferencing and CD-ROM, as there are large differences in the cost per student learning hour across these different media. The technology used should be justified on educational grounds in relation to the expected impacts derived from the medium chosen for delivery.

Equity issues are also of concern in the more developed countries. Studies in developed countries also suggest that information technology can cause substantial increases in inequity (Rodriguez and Wilson, 2000). Some countries have explicit policies to ensure that society does not create new inequalities because of the emergence of a digital divide between those who know and those who do not (Norwegian State Secretary Committee for IT, 1996). In addition, ICT is often encouraged in open learning provisions in developed countries to provide greater opportunities for citizens to pursue lifelong learning.

Education reform to prepare for challenges of the twenty-first century

As the world moves towards an ever more global, more knowledge-based economy, many societies are also experiencing a change in the ability profile of their human resource needs (Riel and

Fulton, 1998). As the creation and dissemination of knowledge are perceived to be of paramount importance, education does not only have to go beyond the framework of initial schooling (ERT, 1997), but the goals and processes of initial schooling should change. Starting from the mid-1990s, there appeared a number of national and regional-level documents detailing masterplans in ICT use in education, which often accompany or precede national/regional changes in the school curriculum. ICT was often perceived in these documents as a crucial vehicle for educational/pedagogical reform (Pelgrum and Anderson, 1999): "… it seems reasonable to assume that in forthcoming years, education systems in many countries will continue to be confronted with pressure to adopt and implement educational programmes that reflect new ways of learning in order to prepare citizens for the information society". A key component of such preparation would be to cater to the growing need for lifelong learning in a world where there is a rapid rise in the amount of information available and a need for more frequent career changes.

Kinelev (2000) declared, "the creation of an education system capable of preparing people to live in the changing world is one of the crucial and urgent tasks of modern society". It is thus not surprising that many governments, in putting forward their IT-in-education masterplans, expound a vision of bringing the nation into the top countries in the world in terms of education. A key focus in such masterplans is the development of a workforce capable of meeting the challenges of the twenty-first century (e.g. PCAST, 1997; Singapore Ministry of Education, 1997; Korean Ministry of Education, 2000). Here, the twenty-first century skills targeted are generally not on specific knowledge or skills, whether technical or conceptual, but more importantly on the learners' metacognitive and affective qualities (e.g. Singapore Ministry of Education, 1997; Education and Manpower Bureau, 1998; Danish Ministry of Education, 1997). The metacognitive qualities included in these policy documents were: creative thinking, lifelong learning abilities and the ability to co-operate and communicate. The affective qualities included were: a sense of social responsibility that includes value judgements and behavioural norms in cyberspace, and the readiness to understand other cultures and ways of life.

To achieve such goals, a large part of the challenge is to bring about a change in the nature of schools and a fundamental change in the school culture. This requires changes in both the goals of education and pedagogical practices, and has to involve everyone in the school, be they teachers or learners.

In some developed countries, such as Finland, where the country already enjoys high education access, an important priority for the implementation of IT in education is to prevent the creation of a social divide that may result from a lack of technical skills, or inequities in access to information for particular sectors of the community. Thus the national education strategies move away from a 'once-and-for-all' mode of training to lifelong learning, and focus attention on ensuring access to cultural services and equal opportunities to use such services. The goal is to establish a 'culture-oriented information society' (Finnish Ministry of Education, 1999). To achieve such goals, in addition to the provision of appropriate ICT infrastructure and the development of basic information skills for all, the implementation needs to include a comprehensive information strategy. For example, in the Finnish information strategy, access to information is a fundamental right of all citizens, and the public library system is regarded as the core of Finnish cultural democracy.

Implementation strategies

Chapter 5 discussed the complexities involved in leading ICT implementation at the school level. Leading change at the national level is far more complex and challenging. In reviewing the ICT implementation strategies that different education systems have employed, one can broadly classify them into four main categories. Some strategies specifically address issues related to funding and resource allocation: whether the implementation should be funded centrally or locally, ways to make more cost-effective provisions for the ICT infrastructure and incentive programmes to encourage change and innovation. The second set of strategies tackles the problem of how to explore and develop viable models of innovation at classroom and school levels. Another set of strategies includes providing mechanisms for supporting development and the sharing of

digital curriculum resources among students and teachers. There is also a set of strategies that some countries have used to support various aspects in the implementation process.

Funding for ICT implementation: centralized versus distributed

Implementation strategies in ICT education policy plans could be broadly categorized as centralized or distributed (which may involve state and/or district levels), similar to the case of system-level educational policy implementation in general. The specific model of implementation adopted for ICT is thus generally dictated by the nature of the education system. For example, both Singapore and Hong Kong have rather centralized education systems, and both have a detailed IT masterplan that prescribes clear strategies, targets, timelines and budget allocations. In Singapore, the IT masterplan calls for a reduction of 10 to 30 per cent of the curriculum content so as to free up curriculum time for the inclusion of ICT within the curriculum, as well as to infuse thinking skills into lessons (Singapore Ministry of Education, 1997). In addition, some policy statements may also specify a target for exploiting ICT as a tool for learning. In this context, both Hong Kong and Singapore have announced expectations that ICT will be used in 25 per cent of curriculum time across various school subjects at the end of the implementation period (Law, 2000*b*).

On the other hand, in many education systems that are centralized in terms of curriculum and education policies, the actual implementation and funding support are delegated to the local, regional or district levels. Japan, Korea, Chinese Taipei and New Zealand are examples of such systems. One issue that arose during implementation in such systems, as well as in systems where there was no centralized education policy, was that there can be wide disparities across regions/districts due to the different resources available locally, as well as the different levels of importance given by the local authority. Many systems have thus developed strategies to stimulate and support system-wide implementation.

Irrespective of the specific policy goals or implementation strategies used, some common strategic elements are found in

essentially all implementation plans: *ICT infrastructure, teacher training, digital curriculum resources, and technical support*, as these are the necessary preconditions for widespread curriculum use of ICT. However, the priorities for resourcing within each of these strategic elements, and the attendant conditions for these to be provided, will differ greatly and will depend on the policy goals as well as the administrative structure of the respective education systems. Some of the prevalent system-wide strategies are discussed in this section.

Funding for ICT implementation: baseline provision of ICT infrastructure and collective bargaining

A popular strategy to ensure access and encourage faster implementation is to set up funding programmes for some baseline provision of ICT infrastructure across the system. For example, Japan, Korea and Chinese Taipei have implemented such plans as part of their national IT masterplans. Some systems have also made use of the collective bargaining power that could be gained with the entire education system as the client base to negotiate for cheap/subsidized Internet access for schools. Examples of this kind of strategy are the E-Rate programme in the USA, and the National Grid for Learning arrangement in England.

Funding for ICT implementation: incentive programmes

Another popular strategy is the provision of incentive programmes by the central government. This is in fact practised in the USA, where even curriculum and educational policies are delegated to the state levels. Here, while the state does influence what happens in its public schools through policies and practices such as funding patterns, legislation and teacher licensing, specific implementation is left to the school districts concerned. The federal government traditionally has had very little direct control or influence over the nation's schools: schools receive only a small percentage of their funding from the national government, and there are no national policies for education. However, as pointed out by Anderson and Dexter (2003), the US Department of Education does influence ICT implementation nationwide through making extra funding available for Congressional or Presidential initiatives, and through crafting and disseminating

national reports and recommendations. The US Federal Government also funded Regional Technology Consortia Programs throughout the country to provide professional development, technical assistance, and information dissemination about ICT.

Developing models of good practices: nationally administered schools as role models

In India, the education system is totally devolved and the central government has no direct influence on schools in the nation, except for the 1,500 (approximately) government schools directly operated by the federal government. The strategy used in India was to establish ICT policies and strategies for the government schools, which would then act as models for other schools nationwide (Mallik, 2003).

Developing models of good practices: pilot projects

There are also strategies used in many systems that were adopted irrespective of whether the system was centralized or not. A very popular strategy in implementation, in centralized and non-centralized systems alike, is the use of pilot projects of various kinds to develop prototypes for implementation, as well as to act as role models for non-pilot schools. One very common form of such projects is the establishment of technology-rich schools to explore the emergence of new models of schools in terms of infrastructure, organization and learning outcomes, where the schools are equipped with state-of-the-art ICT infrastructure to match as closely as possible the 'schools of the future'. Examples of this include the headlight projects in the USA[14], the pilot schools in Hong Kong (Education and Manpower Bureau, 1998; Law, Yuen and Wong, 2001) and the smart schools in Malaysia (Smart School Project Team, 1997).

14. For example, http://www.ed.gov/databases/ERIC_Digests/ed368809.html

Digital curriculum resources: establishing an on-line education resources/education portal site

National education portals, such as the National Grid for Learning[15] in the UK, the Edu.MALL[16] in Singapore, MySchoolNet in Malaysia[17], the EduCities[18] in Chinese Taipei, Kennisnet in the Netherlands[19] and the EdCity[20] in Hong Kong, were generally established with the aim of providing schools, teachers and students with free access to a vast wealth of information, and often involving close partnership with the private sector.

Digital curriculum resources: resources for indigenous language and culture

While the pervasive adoption of Internet technology has led to the increasing connectedness of communities around the world and a redefinition of 'distance', many countries also recognize the threat that such increasing globalization poses to the indigenous language and culture. The pervasive presence of English-language materials on the Internet may lead to an over-dominance of the culture and value embodied by English-language materials on the younger generation. Thus in many countries, there are explicit policy statements to develop electronic resources in the native language and of the native history and culture (for example, Norwegian State Secretary Committee for IT, 1996; Waitayangkoon, 2003).

The development of on-line software platforms for authoring indigenous materials

Malaysia has developed an on-line software platform for the authoring of indigenous materials, titled the ComIL project (Smart Learning Systems, n.d.). This project was put in place in order to

15. http://www.ngfl.gov.uk/
16. http://www.moe.gov.sg/edumall/
17. http://myschoolnet.ppk.kpm.my/
18. http://www.educities.edu.tw/
19. http://www.kennisnet.nl
20. http://www.hkedcity.net/

provide an authoring platform that is both financially affordable and capable of supporting the development of indigenous language content, which is of strategic importance in promoting a nationwide adoption that would not compromise national identity and priority. However, such efforts may also encounter difficulties because of the relatively weaker position of 'minority languages' as well as the lack of market intelligence in such systems. For example, the ComIL project suffered a setback at one stage because of changes in the operating systems that are monopolized by the major international corporations, like Microsoft, which was outside of the control of small economies (Hashim, 2003).

Supporting implementation: recruiting students for technical support

The provision of technical services and support is an important strategic element in the implementation of ICT in schools. This is especially challenging for developing countries in terms of both financial and human resource implications. Some countries have developed training programmes for students to provide volunteer technical support in schools. For example, Malaysia has implemented a DIY-PC Assembly (Hashim, 2003) programme for high-school students, so that they can learn some useful skills while also supporting their own schools in their ICT-development plans. At an international level, the APEC Cyber Education Consortium has also developed a Young Internet Volunteer programme[21] to support ICT-in-education developments in the region.

Supporting implementation: cascading teacher professional development

While formal teacher training has mostly been organized in the form of traditional courses, informal forms of teacher professional development have been reported to be of great importance (Pelgrum, 1999*b*). Often, informal modes of training involve school-based, on-site training by colleagues within the same school. Singapore has developed a cascade model of site-based professional development

21. http://www.acen.or.kr/yiv/

to extend this form of professional development. The government recruits a team of experienced teachers as senior IT instructors or coaches who will fan out to schools to train and help teachers to incorporate ICT-facilitated learning strategies into their learning practices (Singapore Ministry of Education, 1997).

Supporting implementation: leadership development programmes

In countries where the established vision involves changing curriculum goals and pedagogies, among the most pressing challenges of implementation is how to lead various educational institutions to make the institutional changes necessary to become learning organizations (Danish Ministry of Education, 2000). Some policy plans have identified leadership as another important strategic element. For example, the Danish IT masterplan stated that "the favourable disposition and commitment of leadership is decisive if IT development is to become firmly rooted in the core activities of the education sector among teachers, pupils and students ... in the formulation of objectives and strategy and involve the personnel of the institution in achieving a local commitment and clarification of its own goals" (Danish Ministry of Education, 1997). Likewise, both New Zealand (the Principals First programme (Brown, Chamberlain and Shoulder, 2003)) and England (the Virtual Heads[22] and Talking Heads[23] programmes) have also developed programmes for the professional development of school heads to help them realize and face the challenge of leading a school in the information age. At an international level, the need for good practices and role models in leadership is also widely recognized, and a model of a multi-level, integrated approach to practice/change-oriented vision building and strategic planning is being piloted in an APEC Education Foundation-funded e-leadership programme.[24]

Supporting implementation: partnership

As the implementation of a system-wide ICT-in-education plan is very complex and extremely resource-intensive in terms of finance

22. http://www.ncsl.org.uk/index.cfm?pageID=16_VH
23. http://www.ncsl.org.uk/index.cfm?pageid=16
24. Details available from http://acec.cite.hku.hk

and expertise, many countries have included partnership strategies that involve the private sector in their implementation plans. For example, in the five-year IT strategic implementation plan in Hong Kong, one of the strategic elements was identified to be the development of a 'community-wide culture' (Education and Manpower Bureau, 1998). Negotiation and collaboration with the private sector was evident in many aspects of its implementation. The development of the National Grid for Learning in England (Selwyn, 1998), and the E-Rate programme in the USA are also examples of partnership programmes with the private sector.

Another dimension of partnership for enhancing more effective ICT implementation is to establish and/or to take advantage of various international projects and networks. Examples of such networks include the iEARN[25], Thinkquest[26] and the European Schoolnet[27], which organize joint-school collaborative projects or provide frameworks in which schools can set up such projects. There are also a number of networks created specifically to support education developments in developing countries, internationally – such as WorldLink[28] and the International Literacy Institute[29], or regionally – such as the United Nations Economic Commission for Africa.[30] Such partnership initiatives are often referred to as projects that encourage/support the establishment of communities of educational practice. Some of the communities have a strong orientation towards collaborative research and development, which may involve developing a common technological framework and standard[31], or which may focus on promoting general education advancement such as the University and Technology-for-Literacy/Basic Education Partnership in Developing Countries.[32]

25. http://www.iearn.org
26. http://www.thinkquest.org
27. http://www.eun.org
28. http://www.world-links.org
29. http://www.literacy.org
30. http://www.uneca.org
31. For example, the Educational Object Economy Foundation, http://www.eoe.org
32. http://literacy.org/products/ili/webdocs/UTLPcontents.html

ICT policies and national development: issues and challenges

According to Rodriguez and Wilson (2000), rich countries are accumulating more advantages from technology with time. The average growth rate in the Information Technology Productivity (ITP) of developed countries was 23 per cent between 1994 and 1996, while that of poor countries was only 18 per cent over the same period. The result is a widening gap in the global distribution of ICT. The study interpreted the findings as a reflection that ICTs require a sophisticated enabling environment of hardware and policies before they can contribute efficiently to economic growth. There are negative economic, social and political consequences arising from the growing ICT disparities between have and have-not nations. The study shows a gap between rich and poor countries' access to ICT that is staggering. While the average OECD country has about 11 times the per capita income of a South Asian country, it possesses 40 times as many computers, 146 times the mobile phones, and 1,036 times the Internet hosts. On the other hand, even among countries at roughly the same level of economic development with roughly similar economic structures, there are significant differences in ICT availability and utilization. While it is true that rich countries are concentrating more of their gains in technology with time, there is one developing region, East Asia, which seems to be keeping up with the rich countries in this respect.

The impact of ICT on the issue of equity appears to be complex, being very different in developing countries compared to developed countries. While technology has the potential of bringing widened educational opportunities to more remote areas, especially in developed countries, the demands on infrastructure investment often means that for developing countries, the introduction of information technology into schools becomes confined, for a long time, to the urban areas, thus widening the divide between urban and rural areas, introducing a digital divide to the existing economic and educational divides. Developing an appropriate ICT-in-education policy and implementation strategies at a national/systems level is a challenge that no education system can afford to overlook. Based on the discussions in the current

and the previous chapters, policy-makers need to pay careful attention to the following issues and dilemmas when deliberating on ICT-related education policies and strategies.

Entitlement/enabling factor versus non-ready wastage of resources and unproductive use of technology

Access to ICT and ICT-supported educational experiences potentially offers learners valuable opportunities to learn new skills and new competences for effective functioning in the twenty-first century, and should arguably become part of the entitlement of citizens. It is also on this basis that large amounts of money have been allocated to the realization of IT-in-education masterplans in many countries. However, success in implementation depends greatly on the understanding and readiness of the many stakeholders involved in the process. On the other hand, the shelf-life of ICT products and configurations is generally very short. A strongly ICT infrastructure-led development plan may thus lead to wastage of valuable resources if the teachers and principals are not prepared, or if the understanding of the purpose is merely a technological one, such that the impact of the introduction of technology becomes rather limited.

Monitoring measurable targets versus evaluating less tangible outcomes

Another issue that many policy-makers need to tackle is that of monitoring and evaluation. Given the scale of investment normally associated with an IT-in-education masterplan, and the eager anticipation of system-wide impacts resulting from the implementation, there are always strong pressures to monitor and report on the outcomes of the implementation. It is generally relatively easy to develop indicators and to provide data on specific implementation targets for each of the key strategic implementation elements, such as the availability of infrastructure (e.g. computer:student ratio) and the number of hours of staff development available, etc. However, to evaluate whether the goals for implementation have been achieved (i.e. whether students have really achieved the new abilities identified as being important for the twenty-first century, and whether schools have changed into learning organizations capable of continually renewing themselves) is

much more difficult and yet more important for informing policy and practice.

Disseminating good practices versus scaling up innovations

It is common in the education field to identify cases of successful implementation and to disseminate it to others for adoption. It is often anticipated that such dissemination will need to provide detailed descriptions of the physical infrastructure, technical know-how, support available, curriculum context of the implementation and how it was conducted. However, the dissemination of innovation cannot be successful if the learning within or across institutions in this process is simply conceptualized as one of replication. Leadership is essential in innovation adoption as it requires that everyone involved go through a deep learning process and undertake a role change at an individual level, while the institution as a whole will need to undergo a cultural change in order to become a learning organization. For adoption of innovation to be successful, it has to be a creative, innovative process for all those involved in the adoption.

Leadership and change management: centralized versus localized implementation

Another issue that policy-makers need to tackle is the balance between centralized, top-down strategies, and allowing room for local initiatives to flourish. As Fullan (1994) has aptly pointed out, the difficulty with top-down strategies is that the dynamics and complexity of even individual organizations are too big to be totally predictable and controllable. Furthermore, situations are always changing, and this requires complex decision-making at various levels to cope with them. On the other hand, studies have also shown that simply widening participation and empowering people does not guarantee that systemic improvement will occur. A participatory approach to change may be too slow and ill-defined, and prone to failure due to resistance from some of the stakeholders. Fullan thus argued that a 'sandwich' approach is necessary, such that there is a strong consensus on a vision and the direction of change from the top, as well as a strong participatory culture from below, to implement the change.

VII. Looking into the future

In this chapter, an attempt is made to provide a description of the kind of goals and implementation strategies that are likely to be useful for the short to medium term (up to 2015) for two broad contexts: systems that have already attained some level of success in ICT implementation in education, and systems that are just at the beginning stage of ICT implementation.

Introduction

In the previous chapters, the trends and developments of major concern in ICT use in education throughout the world have been reviewed. This chapter makes some projections about the use of ICT in the future. Furthermore, recommendations are also made for strategies concerning further ICT development in education for policy-makers and educational planners. In considering ways forward, the authors have been very much aware of a wide digital divide across nations, and that recommendations need to be differentiated according to the national context and the current state of development.

In a substantial number of countries, computers have already been used in education for more than 15 years. Furthermore, starting from around the mid-1990s, many countries (or more accurately, education systems) began to establish comprehensive ICT-in-education policies/masterplans, which often formed an integral part of national efforts towards adapting/reforming education to satisfy the needs of the information society. ICT was conceived as one of the important facilitating tools that could foster the development of new competences and abilities in learners. It was heartening to note that according to case studies from the IEA and the OECD, groups of early innovators successfully generated innovative educational practices that fostered student-directed learning supported by the use of ICT. However, in many education systems, the effects of these innovations did not become visible immediately. Rather it may be argued that in the period

from 2003 to 2013, many obstacles will still need to be removed before a majority of teachers will be ready to apply new pedagogical approaches. How the influence of these innovations might be extended, such that they become a regular feature in most schools and act as stimuli for further pedagogical and technological innovations, is one of the challenges that the more developed countries face in the implementation of ICT in education.

At the same time, there are countries that are just beginning to develop national policies and strategies for introducing ICT into schools. Many of these countries are economically less developed and suffer from a low density of computers as well as a lack of technical expertise in schools. These countries also face important challenges in education, including the improvement of education access to bring about general language literacy and numeracy. In order to be able to justify economic and human resource investments, the governments in these countries need to be able to demonstrate that ICT can facilitate the solution of these fundamental problems.

In an APEC workshop on e-Educational Leadership[33] held in early 2003, participants coming from 10 member economies in the region worked on identifying the key aspects of good leadership in ICT in education, and on developing cross-national partnerships in leadership in policy-making and the implementation of e-Education initiatives. While participants came from different sectors of the education system (including key ministerial personnel in charge of ICT policies and strategies in education, technology planners and developers, teacher educators and researchers as well as principals and teachers) and from a variety of national developmental contexts[34], there was a strong consensus on the following as guidelines for leadership in ICT in education:

33. For details, see http://acec.cite.hku.hk
34. Delegates participating in the workshop came from the following economies: Chile, China Hong Kong, Chinese Taipei, Indonesia, Japan, Mexico, New Zealand, Philippines, South Korea and Thailand.

- The vision and goals for ICT in education must align with and support the national goals and priorities for educational development.
- The use of ICT for learning and teaching should assist in the solution of key educational problems.
- Learning from innovative experiences of other national or cross-national institutions cannot be accomplished via a simple duplication process. Each local implementation has to take into account the contextual factors and constraints and make appropriate adaptations. In this sense, all successful cases of technology adoption, or 'transfer', are in themselves examples of innovation and change.
- Leadership does not only involve key policy decision-makers within the ministerial set-up or heads of educational institutions, but also the creative input and collaboration of personnel at different levels of the system: technology planners and developers, teacher educators, teachers and researchers.
- Multi-level leadership, as described above, is only possible if there are conscious efforts to devolve decision-making to the lower levels to ensure there is partnership in leadership.
- Technological tools and their uses are not value-free, and implementation goals and priorities should be sensitive to and respect the local culture and values.

There was a high level of consensus among the workshop participants, who were leaders from very different national contextual backgrounds. At the same time, there was recognition of the need for diversity in the specific policies and solutions that countries developed.

For systems that have attained some level of success in ICT implementation in education

Many education systems in the developed world have already achieved a good student:computer ratio of 10 or lower. The major obstacle for ICT in education in the economically advanced countries is no longer a lack of hardware, but rather that the predominant curricula and management/organization structures are still mainly those inherited from the industrial society.

The aims of ICT in education

The good general access and the pervasive use of computers in society at large, coupled with the number of years that computers have been present in schools, have given opportunities to students and teachers alike to attain a general, basic mastery of information technology literacy. However, one may doubt to what extent students in these countries are able to apply their ICT competences, because in quite a number of countries these competences are still taught in isolated subjects and are not integrated into their daily educational practices. Teaching students about the use of technology is not relevant, even for very young children, if there are no meaningful contexts created for them in which to use the technology. The key issue for further development is whether the curriculum reform goals that many systems have established can be achieved with the use of technology in a meaningful and authentic way.

As results from SITES-M2 reveal, irrespective of the state of national development, there were examples in many countries of pedagogical innovations in schools facilitated by the use of ICT aiming to develop the lifelong learning ability of students. In these innovative practices, students became autonomous learners, working collaboratively on authentic learning tasks with peers as well as experts from within and outside of the school. A system-wide priority for these systems at the start of the new millennium is to identify the characteristics and crucial enabling factors for the establishment and transfer of the innovative classroom practices using technology and, in the process, to establish the curriculum goals and pedagogical values encapsulated in these practices as the mainstream educational culture of the system. If this cannot be realized, ICT will remain isolated or, as happened in quite a number of SITES-M2 cases, an extra-curricular activity. Another, less primary but also important goal is to build on the research and experiences accumulated in relation to the development and use of cognitive tools to support more effective learning of important concepts or metacognitive skills.

To summarize, the primary curriculum focus for using technology in education in these systems is ‘learning through technology’,

supplemented by consolidating the achievements made in 'learning with technology'.

Strategies for system-wide implementation (curriculum issues and strategies for change)

The emergence of innovative uses of technology in schools around the world is no guarantee that these practices will be sustainable or transferable. The OECD report on case studies of ICT and organizational change (Venezky and Davis, 2002) provided important insight on strategies for system-wide implementation. First of all, the report pointed out that of the 94 case studies of school-level innovations, ICT rarely acts by itself as a catalyst for educational change. Rather, ICT mostly acted as a lever for the development and growth that the schools had already planned for. Thus ICT might be selected as a key enabling factor or focus for change, but clear educational goals and strategies were evident from the start of the innovation. There was no evidence to affirm that just by installing ICT in a school, innovations and change would follow. This is consistent with research findings that have accumulated since the early introduction of microcomputers (Pelgrum and Plomp, 1993). Indeed, ICT is so versatile and adaptive by nature that it can be tailored to support all kinds of institutional and pedagogical ideologies, including teacher-centred instruction and rote learning. In planning for ICT developments in education at national, regional or school levels, the starting point has to be the establishment of clear curriculum goals and pedagogical priorities, which would not and should not be driven by ICT.

The OECD study (Venezky and Davis, 2002) also reported on the model of ICT diffusion within a school. These authors observed that the traditional diffusion pattern of innovation adoption (as defined by Rogers, 1995) held in most cases. This model divided potential adopters into five categories: innovators, early adopters, early majority, late majority and laggards. Adoption normally begins with a small number of innovators who act as change agents and promote adoption by providing knowledge and training, as well as by reassuring potential adopters that the innovation will meet their interests and needs, and that they are achievable. For an innovation to become sustainable, it

has to go through a process of *routinization*; that is, the innovation has to become incorporated into the regular activities of the school. It was found from the case studies that system-level strategies on curriculum requirements, funding for professional development and ICT infrastructure had important impacts on propagating change and innovation. The different levels in the education systems were generally loosely coupled so that principals and teachers at the school level could develop their own specific innovations according to their own expertise and particular circumstances.

Given that a central goal for ICT implementation is to prepare students for life in a knowledge society, the development of students' and teachers' information literacy; that is, the ability to effectively make use of various information retrieval systems to access and evaluate information, as well as to use knowledge management tools to organize, share and present information, should be a curriculum priority. It is thus important that the role and function of libraries and information professionals at both school and community levels be strengthened.

It is also important at the policy level to recognize the prime importance of strengthening research and development on curriculum implementation and change, for monitoring and assurance purposes as well as to provide a source of continuous input to support the process of change and innovation. For monitoring purposes, there should be efforts to establish some *system-level indicators* on implementation beyond the superficial level of simple student:computer ratios or the percentage of curriculum time during which ICT was used. Indicators that reflect changes in students' and teachers' roles in the learning process, and students' learning outcomes beyond the conventional measures of academic knowledge to include the metacognitive and socio-affective outcomes – often referred to as 'twenty-first century learning outcomes' – would be very valuable in this regard. Another important dimension of research is curriculum innovations and their *routinization*. International efforts in the 1990s to conduct case studies of education innovations at the classroom and school levels (the IEA SITES-M2 and OECD studies respectively) yielded important insight for understanding innovations

beyond the available literature on innovation, which were mainly conducted as action or experimental research. This type of research should be encouraged, and ways to disseminate the findings to promote sustainability and transfer should be more systematically developed.

There is a need for system-level innovation and exploration in new models of assessment. There is an accumulation of research findings that consistently showed a negative correlation between the use of ICT and academic performance. There might be many possible explanations for such results; it is also undeniable that conventional assessment methods do not assess the new, 'twenty-first century learning outcomes'[35]. Without a system-level change in assessment, especially in high-stake public examinations, the *routinization* of innovation would not be possible. This may also be one of the reasons why there were fewer case studies reported at the senior secondary-school level compared to those reported at the lower school levels.

Planning for ICT infrastructure and support

The ICT infrastructure and support in economically developed systems are generally well established, with good Internet connectivity. However, examination of the SITES-M2 case studies also revealed that the technologies used in these systems were mostly derived from general business and office-type application software. Though computer-based cognitive tools, such as simulations and modelling tools, appeared more than 20 years ago, these still played a relatively minor role in terms of the software tools used in the SITES case studies. This contrasted strongly with the uptake of web-browsers, search engines and e-mail programmes for teaching and learning. One possible reason for this low uptake of cognitive tools may be due to the fact that they demand a deeper conceptual understanding in the respective subject areas and more complex facilitation skills on the part of the teachers. More importantly, these cognitive tools are less familiar to teachers as they are not being publicized by commercial enterprises in the same way as in the case of general applications.

35. There is a good collection of research papers on assessment to take account of the effects of technology on student learning in K-12 schools at http://www.sri.com/policy/designkt/found.html

Policy-makers could promote the development, dissemination and installation of these learning tools that are generally constructed on the basis of rich cognitive research findings.

Having established reliable Internet accessibility, many schools have begun to install e-learning platforms. However, most of the e-learning platforms that are commercially available are instruction-focused and teacher-controlled. It is noteworthy that while many countries have invested heavily in the building up of good network connectivity for education, investment in the research and development of educationally sound e-learning platforms is rather low. Research and development on e-learning platforms that support collaborative knowledge building and sharing among learners, and that aid teachers in the provision of scaffolding and facilitation support to learners, should be a priority area in infrastructure development.

With ICT gaining an ever more prominent presence in schools, ICT co-ordination and technical support are becoming vital for the everyday operation of a school. While the former should be closely linked to the educational goals and developmental priorities of the school and is an important part of leadership (to be discussed in the next section), technical support is part and parcel of a good ICT infrastructure. Though many may argue that on-site technical support is desirable, it is most expensive and would not be feasible in situations where the population is geographically dispersed over large areas. Here, the experience of New Zealand in setting up a remote helpdesk[36] may be a viable option. These support platforms could also provide attractive and convenient focal points for the establishment of collaborative teacher professional networks for the sharing of information and experiences.

Another issue that policy-makers face is infrastructure renewal and maintenance. While schools in many developed countries have had computers for instructional purposes for well over a decade, the dramatic increase in the computer:student ratio and the ease of access to the Internet occurred only in the past 5 to 10 years when the 'learning through computers' argument began to take centre stage.

36. For details, see http://www.tki.org.nz/e/r/ict/helpdesk/

Thus in many countries, much of the funding provided to schools for ICT infrastructure has been classified as 'non-recurrent' expenses for which special allocations had been made. Now that the challenge of building up a good ICT infrastructure to ensure adequate access has been largely accomplished, the setting up of a well thought out and sustainable policy for ICT infrastructure maintenance and renewal needs to follow. Unlike school furniture and laboratory equipment, the life-cycles of computer hardware and software tend to be much shorter, necessitating the establishment of more long-term budgeting and technology renewal strategies. We have observed that in some of these countries where the student: computer ratio has improved to well under 10, such as in many of the European countries, there is still a relatively high proportion of computers that are of older makes and less powerful configurations (Pelgrum, 1999*a*). The appropriate life expectancy of computer equipment is certainly debateable, and there are many functions that can be profitably carried out with relatively old models. The cost involved in terms of infrastructure renewal is not simply that of equipment purchase, since the manpower resources necessary to plan, purchase, and install the replacements are significant. Two approaches have been taken by some schools and educational institutions as an alternative to regular purchase of new equipment. One approach was to engage in lease contracts so that the vendors became responsible for the regular upgrading and maintenance of hardware/software.[37] The other approach was to require students to bring their own notebook computers to classes.[38] As family ownership of computers increases and the costs of mobile computer devices drop, this last option would become more feasible and has the advantage of allowing the learner to customize the computer to his/her own personal needs. This form of computer ownership has the additional advantage of reducing the costs of maintenance and the costs associated with the physical accommodation of computers in

37. There are some useful discussion papers on the pros and cons of leasing computers as opposed to purchase: http://www.eddept.wa.edu.au/T2000/infopak/11a_leaseorpurchase.htm http://www.aasa.org/publications/sa/1998_04/Hamilton.htm
38. Most student notebook computer programmes are found at the university level, http://www.hku.hk/caut/Homepage/itt/2_HKU_IBM/2_1Descript.htm provides a comprehensive description of one such programme, as well as a good documentation on the evaluation of the programme in its few years of operation.

computer laboratories, resulting in the faster realization of pervasive computing within the institution. However, this may also lead to a widening digital divide across students from different socio-economic backgrounds. In some cases, the institution provided subsidies to students for the purchase of personal computers in recognition of the fact that the institution would otherwise have to fund a much bigger ICT infrastructure on the school site.

Strategies for supporting school development (leadership issues)

Given that successful ICT implementation needs to be a process of innovation and change, leadership is of paramount importance. Leading change and innovation at the school level requires the establishment of a vision and a mission shared by the principal, most teachers, students, parents and the community, as well as the formulation and implementation of appropriate strategies to realize the vision.

The SITES-M2 case-study data revealed that most of the nominated innovative practices were directly or indirectly related to system or regional-level policies and strategies. These case-study schools might have been involved in pilot ICT-in-education programmes or benefited from the acquisition of hardware/software and access to professional development opportunities through national/regional ICT initiatives. Thus the establishment and promotion of clear goals and priorities for ICT in education and appropriate resources, support and incentives are crucial at the system level. At the same time, the provision of resources and support should be staged on and progressively conditional to the school's ability to demonstrate that the school has clear plans and strategies for implementation that are consistent with the broader curriculum priorities and vision.

Parallel to the above strategies, there should also be efforts to set up leadership and professional development support structures to foster the development of multi-level leadership and partnership in schools. The LeadSpace[39] programme in New Zealand and the Talking Heads

39. http://www.leadspace.govt.nz/index.php

programme[40] in the UK are examples of programmes for principals and headteachers. More specific multi-level leadership programmes may also be developed, grounded on rich case-study research of innovative local and international educational practices using ICT, involving key stakeholders, from the ministry through to principals and teachers, focusing on the issues, considerations and contextual factors for strategic planning in ICT in education. The focus of such programmes should be on the building up of leadership capacities at all levels, empowering individuals within the system through shared decision-making and responsibilities as well as collective risk taking. The ACEC e-Education Leadership programme[41] is an example of such endeavours at a cross-national level, which may be adopted for national, regional and school-level implementation.

Strategies for staff development

It is important to recognize that the purpose of staff development is not simply one of broadening the knowledge base or skills of teachers, but to bring about *deep changes* in teachers' beliefs about what constitutes good education, both in terms of its goals and the desired roles of teachers in the information age, as well as in actually practising such rhetoric in their classrooms. Even if there are plenty of classroom examples of good practices, the 'transfer' of innovative practices from one teacher to another or from one school to another cannot be a simple process of replication. The teachers concerned still need to internalize the values and essence of the practice to be adopted and make adaptations to suit the specific circumstances of the teacher, the students and the school concerned. Thus the 'transfer' process itself is also a process of innovation. Effective learning for this type of professional development has to be experiential, and it can only take place through reflective practice during the process of innovation and adaptation. Effective professional development programmes therefore need to be organized in tandem with curriculum reform initiatives. Professional development support should be structured in a way that encourages collaborative curriculum innovation and risk taking, as well as shared reflection on action. There have been many

40. http://www.headteachers.ac.uk
41. http://acec.cite.hku.hk

initiatives concerned with the establishment of communities of practice in conjunction with design experiments in education[42] in developed countries, where this type of professional development support has been found to be essential. These were generally structured as action research projects, providing a personal learning experience for teachers who were keen to 'walk the talk' in experimenting with new models of learning and teaching in schools, and to participate simultaneously in teacher networks as members of a learning community.

For systems that are at the beginning stage of ICT implementation in education

Education at the turn of the millennium in economically less developed countries was very different from that in developed countries. Even the provision of a basic education to all school-age children is still a serious challenge in many economically less advanced countries. On the other hand, it would not be wise or in the interest of national development to not give any consideration to the introduction of ICT in basic education. Policies and strategies for ICT in education should be developed as an integral component of a national plan to leverage technology and education in order to narrow the digital gap between themselves and developed countries and thus accelerate national development.

The aims of ICT in education

As mentioned earlier, the aims of ICT implementation should align with and promote broader national educational goals and priorities. For developing countries, promoting general literacy is definitely a key national priority. ICT-based programmes and software have been established in economically developed countries for enhancing learning and teaching effectiveness in basic education. However, such programmes are not

42. Examples include the various Technology in Schools projects in Western Australia http://www.eddept.wa.edu.au/tisp/index.htm, especially the Innovation in the Classroom project http://www.eddept.wa.edu.au/tisp/innovate.htm, the Institute for Knowledge Innovation and Technology http://ikit.org/, and the Design Sciences for Human Learning project in the USA http://gse.gmu.edu/research/de/

suitable for developing countries, not only because these are generally not available in the local indigenous language, but they also require a high computer:learner ratio to operate. Rather, a mix of various technologies including more conventional media such as print, radio and television broadcasting, as well as digital satellite communication technologies such as the Internet, can be used to more effectively extend educational opportunities to a much wider population – especially to those living in remote areas of the country – in the form of various modes of distance education delivery.[43] Uses of ICT to extend distance education opportunities can be categorized as 'learning with technology' as it makes education more accessible.

While 'learning about technology' is no longer the primary goal for developed countries, it is still an important challenge that developing countries cannot overlook. This includes achieving information literacy goals at the basic education level, as well as training of personnel for businesses and IT industries. The latter should be part of the more immediate economic and human resource development plan, and is often taken care of as part of vocational or higher education. The former is essential to ensure that the younger generation will not grow up as technological illiterates, and that they will at least have an understanding and appreciation through some rudimentary experience of having access to the wide world of knowledge and information via the Internet. How this goal might be achieved will be discussed in a later section.

In developed countries, the major aims to be achieved through the use of technology are nurturing critical thinking skills and lifelong learning abilities, often referred to as twenty-first century abilities. For developing countries, it would not be feasible to provide the level of technological infrastructure necessary to support the development of such abilities via the 'learning through technology' approach used in developed countries. On the other hand, it is possible for developing countries to undertake curriculum and assessment reforms that foster the development of higher-order abilities through the introduction of

43. The Global Distance EducationNet is a project of the World Bank's Human Development Network Education Group (http://www1.worldbank.org/disted/home.html), providing a knowledge guide to distance education.

productive learning experiences and authentic learning tasks in the school curriculum. One should be aware that a substantial number of these twenty-first century abilities do not necessarily require a dense and sophisticated ICT infrastructure. It is also worth noting that, although in the richer economies quite a number of ICT-supported education reform initiatives have been undertaken, the blueprint for the school of the future has not yet been found. Therefore, for the weaker economies, a general strategy might be to follow the 'experiments' of the stronger economies and focus in particular on those which seem to be very successful and, in principle, also adaptable and transferable to other educational contexts.

Strategies for system-wide implementation (curriculum issues and strategies for change)

Achieving the curriculum objectives described above as expediently as possible with very limited resources and constraints in terms of technical expertise is a serious challenge to those leading education developments in developing countries. Resource deployment should be carefully considered so that funds are not spent excessively on the purchase of computer hardware and software which have a short shelf-life of only a few years. Priority should be given to the most cost-effective uses of technology that will extend education opportunities to the population. Different goals and strategies may need to be established to cater to the different needs of cities and remote areas within this broader priority framework. In particular, there may be specific human resource needs for IT-competent personnel for business and industrial developments that lie within the national priority for development. Such needs could be adequately met through a combination of conventional delivery methods and distance education strategies. The introduction of strategic ICT training courses for identified national IT development needs will bring in ICT infrastructure, including Internet access, to related educational institutions (mostly tertiary or vocational). To enable such scarce resource to be used in the most cost-effective way, they should be considered as part of the local community resource so that schoolchildren and the broader community can have access to these during different times of the day to maximize their usage and impact.

A focal implementation strategy for IT in education should be the establishment of a broadly based partnership network to gather support for infrastructure as well as technical expertise. Such a network should also be used to help students at senior high school to take up projects from businesses, thus providing authentic learning tasks in national contexts. Leaders from different sectors such as businesses, universities and colleges, schools and ministries of education may also be consulted to advise on human resource development priorities and strategies.

Another important strategic dimension is to develop IT literacy in schools. Here, the 'hole in the wall' project[44] undertaken by Sugata Mitra in India provides significant insight for policy-makers. In this project, a high-powered Pentium computer with a fast Internet connection was mounted onto a wall and free access was given to poor street children without any explanation whatsoever. It was found that under such circumstances, groups of curious children could train themselves to operate a computer at a basic level (Mitra, 2000) and get a reasonably good idea about the concept of browsing and the nature of the Internet, even though they may not even know the proper terminology. This was a very encouraging finding as it demonstrated that economically deprived children without any contact with anyone having the slightest computing expertise could still learn to master functional information literacy if they were given ready access and the freedom to explore.

While computer access and Internet connectivity are limited, it is still important for developing countries to undertake curriculum reform to promote the development of critical thinking skills and lifelong learning abilities in basic education. It is suggested here that partnerships can be formed with businesses and non-governmental organizations to contribute authentic contexts, problems and resources for updating the school curriculum. It is heartening to note from the SITES-M2 case studies that, given some rudimentary resources and support, innovative classroom practices could still emerge in developing countries. These practices can then act as models for other schools, as well as provide important data and experiences for policy-makers in furthering developments in this area.

44. http://www.niitholeinthewall.com/

A further challenge faced by developing countries is the language barrier. With the exception of very few countries such as India and the Philippines, English is not the medium of instruction in schools. The availability of software, learning resources and web pages in the local indigenous language is often very limited. While it is not possible to simply embark on major translation efforts, many developing countries, such as Thailand, have made national efforts to develop digital curriculum resources for the teaching of the local language and culture. The pervasive influence of the Internet has been perceived as a serious challenge to the survival of the local language, culture and values.

Planning for ICT infrastructure and support

Access to computers and the Internet is essential, though insufficient, to attain the various curriculum goals mentioned. The training of IT personnel in vocational or higher education might have more specific demands on the type of hardware/software infrastructure necessary to support learning. However, the curriculum goals of computer literacy and 'learning through technology' demand primarily free and ready access to a computer with basic office-type applications and Internet access. All possible efforts should be made to ensure that computers and the Internet are accessible to students as long as they are located in an area which has an electricity supply. This can be done through various partnership and donation schemes, whereby outdated computers and peripherals phased out in businesses and in developed countries are donated to schools directly or to community organizations.

Internet access in remote areas often relies on satellite transmission. Where it would not be economically viable to provide uninterrupted Internet access, it might be possible to provide pseudo access through setting up a local mirror of important resources and updating this mirror regularly.

The utilization of resources can be further maximized through the scheduling of classes in centralized locations and, where possible, some open access areas for all students. At least one machine should be located in a staff room or in other locations where teachers can

have ready access to it. It would be best if the same infrastructure could be used to increase community access to computers after school hours. These measures are possibly more effective than running technical skills development courses for teachers.

Maintenance and support for the hardware/software and networking is another major difficulty. IT personnel has generally been a scarce commodity in developing countries, and it would not be realistic to provide all schools with a technologically competent IT co-ordinator. One proven way of dealing with the problem is to train up 'young technology volunteers' for each class/school so that the volunteers can develop better skills as well as contribute to improving access for all students and the community.[45]

Strategies for supporting school development (leadership issues)

Unlike developed countries, the flow of information among schools in different localities tends to be relatively slow. As a consequence of the much weaker information structure and literacy level of the general population, it may not be realistic to expect schools to access the vast amounts of information on curriculum change and technology available on the web and to take advantage of national/regional school-development incentives (if available) autonomously as in developed countries. Local education offices and teacher education institutions in these countries should play an important role in supporting school development. A key strategy in leading change at the school level would be to provide at least some minimum information technology access to the principals and teachers. This should be coupled with major efforts at all levels of government to encourage partnership and community aid from businesses, local and international organizations to support education developments in one or more of the following aspects: provision of hardware/software (new or used), Internet access, and technical and educational expertise. The government may also set up regional centres for the dissemination of good practices.

45. The APEC Youth Internet Volunteer (YIV) is an international programme that provides ICT-skills training for schoolteachers and students in the APEC region: http://www.apecsec.org.sg/whatsnew/announce/yiv.html

Strategies for staff development

In many developing countries, teachers are often willing to undertake ICT training. However, after completing their training and obtaining the appropriate certification, they are often attracted by higher salaries and leave teaching to work in the business sector. The training received by teachers in these situations is usually non-education specific, providing knowledge and skills to teach computing in schools. Many teachers in the past complained that training courses were much too technical and lacked a focus on the pedagogical/didactical aspects of integrating ICT into daily educational practices. It is suggested here that efforts should be made to provide opportunities for all interested teachers to learn about ICT-supported didactical approaches that are proven to be relevant and practical. Such training should be organized as school-based efforts so that there will be a broader base of teachers to contribute to its implementation, and more teachers can be involved in developing ways of using the limited IT infrastructure to benefit students to the maximum.

Conclusion

Looking into the future, the way in which ICT is leveraged to bring about educational change and innovations will have important impacts on a country's social and economic developments. While there is evidence of a widening digital divide between countries, the authors still remain hopeful that careful strategic planning and implementation of ICT in education will narrow this divide and help broaden and improve the educational opportunities for all.

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