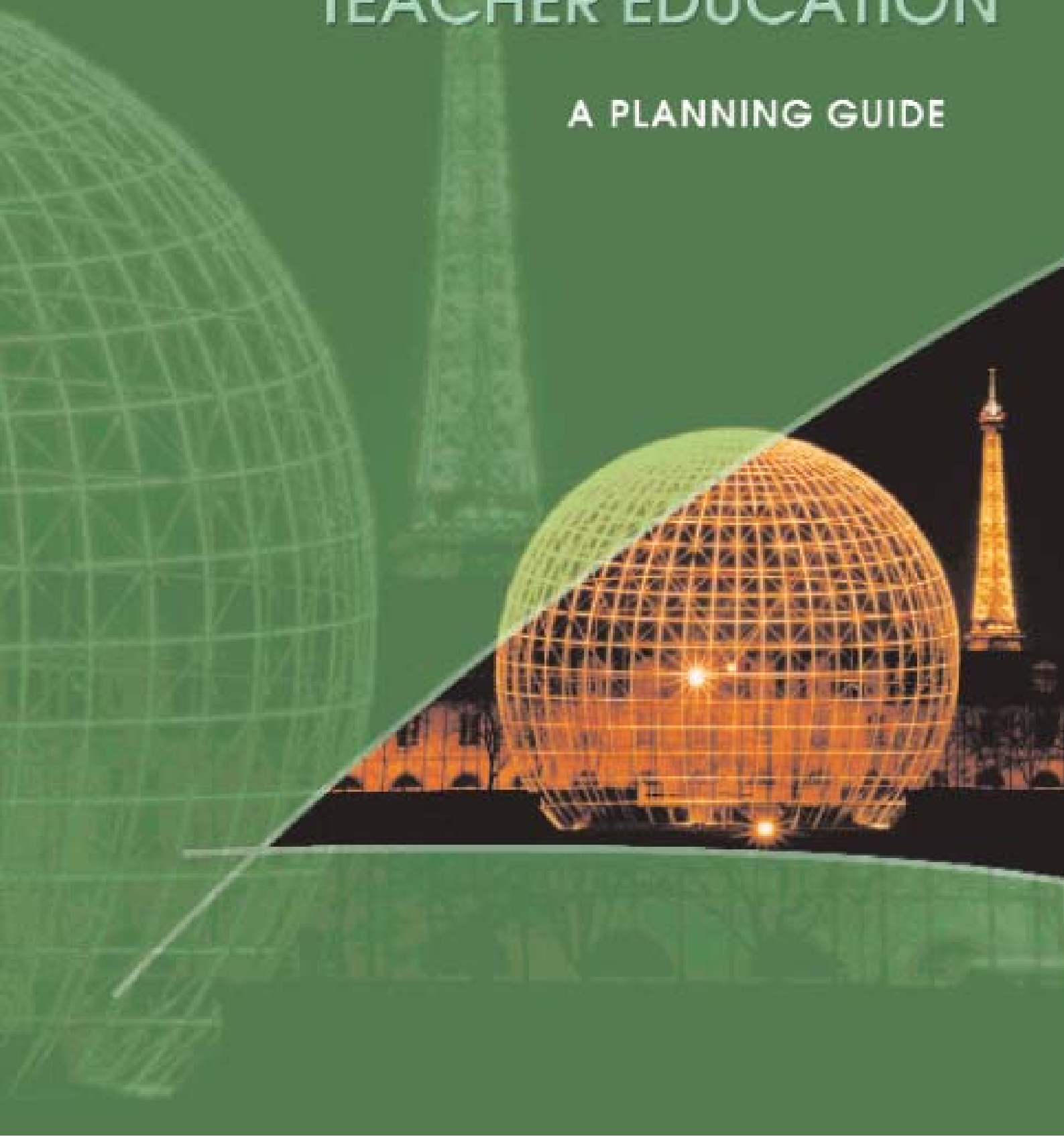




United Nations
Educational
Scientific and Cultural
Organization

INFORMATION AND COMMUNICATION TECHNOLOGIES IN TEACHER EDUCATION

A PLANNING GUIDE



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UNESCO

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FOREWORD

Improving the quality of education through the diversification of contents and methods and promoting experimentation, innovation, the diffusion and sharing of information and best practices as well as policy dialogue are UNESCO's strategic objectives in education.

Educational systems around the world are under increasing pressure to use the new information and communication technologies (ICTs) to teach students the knowledge and skills they need in the 21st century. The 1998 UNESCO World Education Report, *Teachers and Teaching in a Changing World*, describes the radical implications ICTs have for conventional teaching and learning. It predicts the transformation of the teaching-learning process and the way teachers and learners gain access to knowledge and information.

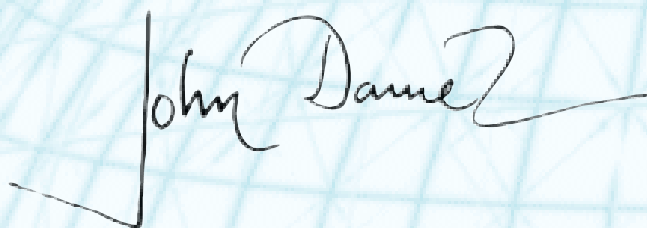
With the emerging new technologies, the teaching profession is evolving from an emphasis on teacher-centred, lecture-based instruction to student-centred, interactive learning environments. Designing and implementing successful ICT-enabled teacher education programmes is the key to fundamental, wide-ranging educational reforms.

Teacher education institutions may either assume a leadership role in the transformation of education or be left behind in the swirl of rapid technological change. For education to reap the full benefits of ICTs in learning, it is essential that pre- and in-service teachers are able to effectively use these new tools for learning. Teacher education institutions and programmes must provide the leadership for pre- and in-service teachers and model the new pedagogies and tools for learning.

Some practical answers to the increasing challenges posed by the new technologies to the teaching profession are offered in the present publication, entitled *Information and Communication Technologies in Teacher Education: A Planning Guide*. The document provides resources to help teacher educators, administrators and policy-makers better apply ICTs to teacher education programmes. The resources were developed by an international group of experts with extensive experience in the integration of ICTs into teacher preparation programmes.

The document proposes a framework for ICTs in teacher education, describes the essential conditions that must be met for successful technology integration and provides guidelines for the development of a strategic planning process. It also identifies important strategies for managing the change process in the teacher education programme as technology becomes a catalyst for transforming the teaching-learning process.

UNESCO would like to thank the contributors to this document, which we hope will generate great interest in Member States and will largely contribute to achieving UNESCO's main and overwhelming priority – the drive to meet the challenges of scope and scale of Education for All.

A handwritten signature in black ink, reading "John Daniel", with a stylized flourish at the end.

John Daniel
Assistant Director-General for Education

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INTRODUCTION

Educational systems around the world are under increasing pressure to use the new information and communication technologies (ICTs) to teach students the knowledge and skills they need in the 21st century. The 1998 UNESCO World Education Report, *Teachers and Teaching in a Changing World*, describes the radical implications the new information and communication technologies have for conventional teaching and learning. It predicts the transformation of the teaching-learning process and the way teachers and learners gain access to knowledge and information. It states:

New possibilities are emerging which already show a powerful impact on meeting basic learning needs, and it is clear that the educational potential of these new possibilities has barely been tapped. These new possibilities exist largely as the result of two converging forces, both recent by-products of the general development process. First the quantity of information available in the world-much of it relevant to survival and basic well-being-is exponentially greater than that available only a few years ago, and the rate of its growth is accelerating. A synergistic effect occurs when important information is coupled with the second modern advance-the new capacity to communicate among the people of the world. The opportunity exists to harness this force and use it positively, consciously, and with design in order to contribute to meeting defined learning needs (1998 UNESCO World Education Report, p. 19).

To effectively harness the power of the new information and communication technologies (ICTs) to improve learning, the following essential conditions must be met:

- Students and teachers must have sufficient access to digital technologies and the Internet in their classrooms, schools, and teacher education institutions.
- High quality, meaningful, and culturally responsive digital content must be available for teachers and learners.
- Teachers must have the knowledge and skills to use the new digital tools and resources to help all students achieve high academic standards.

Teacher education institutions are faced with the challenge of preparing a new generation of teachers to effectively use the new learning tools in their teaching practices. For many teacher education programmes, this daunting task requires the acquisition of new resources, expertise and careful planning.

In approaching this task it is helpful to understand:

- the impact of technology on global society and the implications for education
- the extensive knowledge that has been generated about how people learn and what this means for creating more effective and engaging student-centred learning environments
- the stages of teacher development and the levels of adoption of ICTs by teachers
- the critical importance of context, culture, leadership and vision, life-long learning, and the change process in planning for the integration of technology into teacher education
- the ICT competencies required of teachers related to content, pedagogy, technical issues, social issues, collaboration, and networking
- the importance of developing standards to guide implementation of ICTs in teacher education
- the essential conditions for successful integration of ICTs into teacher education
- important strategies to consider in planning for the infusion of ICTs in teacher education and managing the change process.

This document is designed to provide a guide to help teacher educators, administrators and policy-makers infuse, integrate, or embed ICTs into teacher education. The resources were developed by an international group of experts with extensive experience in the integration of ICTs into teacher preparation. The document provides a framework for ICTs in teacher education and describes the essential conditions that must be met for successful technology integration. It offers case studies illustrating the variety of approaches that may be used in integrating ICTs into teacher education and provides guidelines for the development of a high quality strategic technology plan. Lastly, it discusses the importance of planning and managing the change process and building a broad base of support among all stakeholders to achieve the goals of integrating ICTs into the teacher education programme.

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ICTs AND TEACHER EDUCATION: GLOBAL CONTEXT AND FRAMEWORK

Information and communication technologies (ICTs) are a major factor in shaping the new global economy and producing rapid changes in society. Within the past decade, the new ICT tools have fundamentally changed the way people communicate and do business. They have produced significant transformations in industry, agriculture, medicine, business, engineering and other fields. They also have the potential to transform the nature of education-where and how learning takes place and the roles of students and teachers in the learning process.

Teacher education institutions may either assume a leadership role in the transformation of education or be left behind in the swirl of rapid technological change. For education to reap the full benefits of ICTs in learning, it is essential that pre-service and in-service teachers have basic ICT skills and competencies. Teacher education institutions and programmes must provide the leadership for pre-service and in-service teachers and model the new pedagogies and tools for learning. They must also provide leadership in determining how the new technologies can best be used in the context of the culture, needs, and economic conditions within their country. To accomplish these goals, teacher education institutions must work closely and effectively with K-12 teachers and administrators, national or state educational agencies, teacher unions, business and community organizations, politicians and other important stakeholders in the educational system. Teacher education institutions also need to develop strategies and plans to enhance the teaching-learning process within teacher education programmes and to assure that all future teachers are well prepared to use the new tools for learning.

GLOBAL CONTEXT

As noted in the UNESCO World Education Report, *Teachers and Teaching in a Changing World* (UNESCO, 1998), the young generation is entering a world that is changing in all spheres: scientific and technological, political, economic, social, and cultural. The emergence of the 'knowledge-based' society is changing the global economy and the status of education.

These new possibilities exist largely as the result of two converging forces. First the quantity of information available in the world-much of it relevant to survival and basic well-being-is exponentially greater than that available only a few years ago, and the rate of its growth is accelerating. A synergistic effect occurs when important information is coupled with a second modern advance-the new capacity to communicate among people of the world. The opportunity exists to harness this force and use it positively, consciously, and with design, in order to contribute to meeting defined learning needs.

As is the case for other sectors of the wider economy and society, education will need to come to terms with the new technologies. This could require substantial public and private sector investments in software research and development, purchase of hardware, and refurbishment of schools. It will be difficult for national policy-makers to resist finding the necessary resources, whatever their sensibilities for expenditure on education, although without international co-operation and assistance the poorest countries could fall still further behind. Parents and the public at large, in the industrial countries at least, are unlikely to accept for too long the notion that education should be less well equipped with the new technologies than other areas of social and economic activity (UNESCO World Education Report, 1998, pp. 19-20).

There is growing awareness among policy-makers, business leaders and educators that the educational system designed to prepare learners for an agrarian or industrially-based economy will not provide students with the knowledge and skills they will need to thrive in the 21st century's knowledge-based economy and society. The new knowledge-based global society is one in which:

- the world's knowledge base doubles every 2–3 years;
- 7,000 scientific and technical articles are published each day;
- data sent from satellites orbiting the earth transmit enough data to fill 19 million volumes every two weeks;

- graduates of secondary schools in industrialized nations have been exposed to more information than their grandparents were in a lifetime;
- there will be as much change in the next three decades as there was in the last three centuries (National School Board Association, 2002).

The challenge confronting our educational systems is how to transform the curriculum and teaching-learning process to provide students with the skills to function effectively in this dynamic, information-rich, and continuously changing environment.

The technology-based global economy also poses challenges to countries as national economies become more internationalized, with the increasing flow of information, technology, products, capital, and people between nations. This new economic environment is creating a new era of global competition for goods, services, and expertise. All of these changes are producing dramatic shifts in the political, economic and social structures of many countries around the world. In industrialized nations, the economic base is shifting from industry to information. This shift also demands new knowledge and skills in the work force. ICTs have changed the nature of work and the types of skills needed in most fields and professions. While they have, on the one hand, created a wide array of new jobs, many of which did not even exist ten years ago, they have also replaced the need for many types of unskilled or low-skilled workers. For example, the new 'smart' agricultural equipment, using advance digital and industrial technology, is able to do the work previously done with a large number of low-skilled agricultural workers. In addition, new manufacturing plants are requiring fewer low-skilled workers. A Canadian study notes, for example, that in high-tech companies only 10% of the work force is comprised of unskilled workers (National School Board Association, 2002). These trends pose new challenges to educational systems to prepare students with the knowledge and skills needed to thrive in a new and dynamic environment of continuous technological change and accelerating growth in knowledge production.

Education is at the confluence of powerful and rapidly shifting educational, technological and political forces that will shape the structure of educational systems across the globe for the remainder of this century. Many countries are engaged in a number of efforts to effect changes in the teaching/learning process to prepare students for an information and technology-based society. The UNESCO World Education Report (1998) notes that the new technologies challenge traditional conceptions of both teaching and learning and, by reconfiguring how teachers and learners gain access to

knowledge, have the potential to transform teaching and learning processes. ICTs provide an array of powerful tools that may help in transforming the present isolated, teacher-centred and text-bound classrooms into rich, student-focused, interactive knowledge environments. To meet these challenges, schools must embrace the new technologies and appropriate the new ICT tools for learning. They must also move toward the goal of transforming the traditional paradigm of learning.

To accomplish this goal requires both a change in the traditional view of the learning process and an understanding of how the new digital technologies can create new learning environments in which students are engaged learners, able to take greater responsibility for their own learning and constructing their own knowledge. Thomas Kuhn suggests that revolutions in science come about when the old theories and methods will not solve new problems. He calls these changes in theory and methods a "paradigm shift." There is widespread concern that the educational experiences provided in many schools will not prepare students well for the future. Many educators and business and government leaders believe that creating a paradigm shift in views of the learning process, coupled with applications of the new information technologies, may play an important role in bringing educational systems into alignment with the knowledge-based, information-rich society.

THE TRADITIONAL VIEW OF THE LEARNING PROCESS

The existing view of the learning process emerged out of the factory model of education at the turn of the 20th century and was highly effective in preparing large numbers of individuals with skills needed for low-skilled positions in industry and agriculture. The innovation of classrooms with 20-30 students was created along with the concept of standardized instruction for everyone. The traditional, teacher-centred approach to learning is illustrated in Figure 1.1. As shown, the teacher is the expert and the dispenser of knowledge to the students. It is largely a 'broadcast' model of learning where the teacher serves as the repository and transmitter of knowledge to the students. The traditional educational paradigm is often characterized by the following views of learning:

- *Learning is hard.* Many view learning as a difficult and often tedious process. According to this view, if students are having fun or enjoying what they are doing in a learning activity, they probably are not learning.

- *Learning is based on a deficit model of the student.* The system strives to identify deficiencies and weaknesses of the student. Based on noted deficiencies, students are tracked, categorized, remediated or failed. The impact of the deficit model of student learning is most obvious in compensatory education programmes. As implied by the term, compensatory education is designed to make up or remediate learning that some children, particularly poor minority children, do not have, but which the curriculum and structure of schooling assume are common to all children.

Bruer, in his book, *Schools for Thought*, notes that research overwhelmingly concentrates on the weaknesses of poor children. Very little research has been done on their strengths. In addition, the weaknesses identified are often deficiencies in terms of the traditional organization and content of schooling. Very little thought has been given to the idea of changing schooling to accommodate new kinds of students; all the effort has gone to changing the students so that they will fit into the schools. In addition, the underlying assumptions about poor students' motivation, language, and conceptual development have..."militated against offering them a literacy of thoughtfulness and have favoured a low-level, atomized, concrete, basic-skills curriculum. The language of that curriculum has been so simplified that it is both boring and artificial. It has been stripped of its richness and context and made fundamentally meaningless, which is to say unabsorbable by normal people, except through memorization, whose effects last only a few hours or days." (Bruer, 1993)

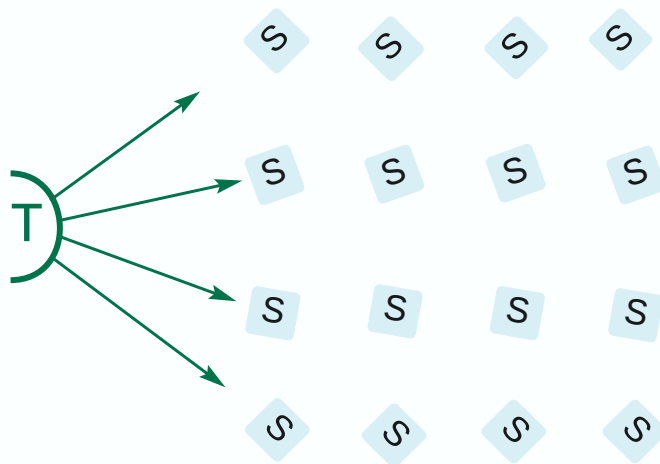


Figure 1.1 Information Transfer Model of Learning

- *Learning is a process of information transfer and reception.* Much of our present learning enterprise remains "information-oriented," emphasizing students *reproducing knowledge* rather than *producing their own knowledge*. It also remains teacher-centred. Many still see the role of the teacher as a dispenser of information and the role of the student as a passive receiver, storer and repeater of the transmitted information (see Figure 1.1). The prevalence of this view is supported by observations that teachers continue to rely on old standbys such as lectures, textbook reading, and fill-in-the-worksheets practices that reduce students to passive recipients of information and fail to develop their thinking skills.
- *Learning is an individual/solitary process.* In a study of schools in the United States, the National Assessment of Educational Progress noted that most students spend long hours working alone at their desks completing worksheets or repetitive tasks. A London Times survey of English school children indicated that students almost unanimously rejected this daily ordeal of dull and ritualistically solitary classroom activity and called for a broader and more exciting curriculum. Above all, they wanted more work allowing them to *think for themselves*. They wanted to design and make things, to experiment and to engage in first-hand observation. The Times reported, however, that there was little evidence of changes in the curriculum that would respond to the students' wishes. (Resta, 1996)
- *Learning is facilitated by breaking content/instruction into small isolated units.* The educational system is often geared more to categorizing and analyzing patches of knowledge than to sewing them together. Bruer (1993) notes that the technology of mass education is quite adept at "breaking knowledge and skills into thousands of little standardized, decontextualized pieces, which could be taught and tested one at a time."

Neil Postman in his book, *Teaching as a Subversive Activity*, states that our educational systems break knowledge and experience into "subjects, relentlessly turning wholes into parts, history into events without restoring continuity." (Postman, 1969)

- *Learning is a linear process.* Frequently, the textbook or teacher provides only one linear path through a narrowly bounded content area or sequence of standardized instructional units. For example, in a mathematics text only one correct problem solution trail may be offered for a specific subclass of problems. However, the problems

encountered in daily life (or in mathematics) seldom have only one solution path or sequence.

CHANGES IN VIEWS OF THE LEARNING PROCESS

In contrast to the traditional teaching-learning paradigm, a new paradigm of the teaching-learning process is emerging, based on three decades of research in human learning, that encompasses the following views of the human learning process:

- *Learning is a natural process.* The natural state of the brain is to learn, however, not everyone learns in the same way. There are different learning, perceptual and personality styles that must be considered in the design of learning experiences for the individual student. Given interesting and rich learning environments, and supportive and stimulating teachers, students will learn. Teachers have often noted that children who appear disruptive or to have short attention spans when confronted with typical classroom instruction, may spend long periods engaged in meaningful and interesting computer-related activities.
- *Learning is a social process.* The communal context of knowledge and learning is beginning to be rediscovered, as evidenced by the rapid growth of quality circles and computer-supported collaborative work in business, government, medicine, and higher education. As Vygotsky (1978) noted long ago, students learn best in collaboration with peers, teachers, parents, and others when they are actively engaged in meaningful, interesting tasks. ICTs provide opportunities for teachers and students to collaborate with others across the country and across the globe. They also provide new tools to support this collaborative learning in the classroom and online.
- *Learning is an active and not a passive process.* In most fields, people are faced with the challenge of *producing knowledge* rather than simply *reproducing knowledge*. To allow students to move toward competence, they must be actively engaged in the learning process, in activities such as solving real problems, producing original writing, completing scientific research projects (rather than simply studying about science), dialoguing with others on important issues, providing artistic and musical performances, and constructing physical objects. The traditional curriculum asks students only to recall and describe what others have accomplished or produced. While all pro-

duction of knowledge must be based on an understanding of prior knowledge, the mere reproduction of knowledge, without its connection to the production of knowledge, is largely a passive activity that neither fully engages nor challenges the student.

- *Learning may either be linear or non-linear.* Much of what now happens in schools appears based on the notion that the mind works like a serial processor that is designed to process only one piece of information at a time in sequential order. But the mind is a wonderful parallel processor that may attend to and process many different types of information simultaneously. Cognitive theory and research sees learning as a reorganization of knowledge structures. The knowledge structures are stored in semantic memory as schema or cognitive maps. Students "learn" by augmenting, combining, and rearranging a collection of cognitive maps, many of which overlap or are interconnected through a complex network of associations. There are many ways that students may acquire and process information and assimilate it into their existing knowledge structures. Although some knowledge domains, such as mathematics, may perhaps lend themselves to a linear approach, not all learning can or should occur linearly.
- *Learning is integrative and contextualized.* Pribram's holistic brain theory suggests that information presented globally is more easily assimilated than information presented only in a sequence of information elements (Pribram, 1991). It is also easier for students to see relations and to make connections. Jacob Bronowski (1990), in *Science and Human Values*, made the point that to discover the connection between what had seemed two isolated facts of existence is a creative act, whether the field is art or science. He calls it an act of unifying. This is not something that can be done for learners; these connections cannot be made in learners' minds. Information can be given, the connection can even be stated. But even if the information is repeated, it cannot be assumed it is really known. The learners must discover it for themselves. That is not to say that learners must discover everything unaided. The teacher's role is to help them in several ways to make connections and to integrate knowledge.
- *Learning is based on a strength model of student abilities, interest, and culture.* Based on the work of Howard Gardner and others, schools are beginning to consider the specific strengths and interests that students bring to the learning environment, and are designing learning activities that build on student strengths rather than focusing only upon remediating weaknesses. In addition, schools increasingly rec-

ognize diversity as a resource rather than a problem in the classroom. In contrast to the remedial and standardized concept of instruction, diversity and individual differences are valued and the learning process is designed to build on the strengths and assets brought by the learner to the classroom.

- *Learning is assessed through task completion, products, and real problem solving of both individual and group efforts.* Rather than simply evaluating students through paper and pencil tests, assessments are made using portfolios of actual performances and work in both collaborative and individual learning tasks.

The traditional view of the learning process is typically teacher-centred, with teachers doing most of the talking and intellectual work, while students are passive receptacles of the information provided. This is not to indicate that the traditional lecture method is without value, as it allows the teacher to quickly convey lots of information to students and is a useful strategy for recall or rote learning. However, it is not the most effective way to help students develop and use higher order cognitive skills to solve complex realworld problems. As noted by Driscoll (1994), we no longer can view learners as "empty vessels waiting to be filled, but rather as active organisms seeking meaning."

Don Tapscott, in his book *Growing Up Digital: The Rise of the Net Generation* (1998), notes that we are entering a new era of digital learning in which we are in the process of transitioning from "broadcast" learning to "interactive" learning. Today's students no longer want to be passive recipients in the information transfer model of learning. Rather they want to be active participants in the learning process. There is growing recognition that today's world requires that students be able to work collaboratively with others, think critically and creatively, and reflect on their own learning processes.

A SHIFT FROM TEACHING TO LEARNING

As technology has created change in all aspects of society, it is also changing our expectations of what students must learn in order to function in the new world economy. Students will have to learn to navigate through large amounts of information, to analyze and make decisions, and to master new knowledge domains in an increasingly technological society. They will need to be lifelong learners, collaborating with others in accomplishing complex tasks, and effec-

tively using different systems for representing and communicating knowledge to others. A shift from teacher-centred instruction to learner-centred instruction is needed to enable students to acquire the new 21st century knowledge and skills. The following table (Sandholtz, Ringstaff, and Dwyer, 1997) identifies the shift that will take place in changing from a focus on teaching to a focus on learning.

Table 1.1 Teacher-Centred and Learner-Centred Learning Environments

	Teacher-centred learning environments	Learner-centred learning environments
Classroom activity	Teacher-centred, Didactic	Learner-centred, Interactive
Teacher role	Fact teller, Always expert	Collaborator, Sometimes learner
Instructional emphasis	Facts' memorization	Relationships, Inquiry and invention
Concepts of knowledge	Accumulation of facts, Quantity	Transformation of facts
Demonstration of success	Norm referenced	Quality of understanding
Assessment	Multiple choice items	Criterion referenced, Portfolios and performances
Technology use	Drill and practice	Communication, access, collaboration, expression

Shifting the emphasis from teaching to learning can create a more interactive and engaging learning environment for teachers and learners. This new environment also involves a change in the roles of both teachers and students. As shown in Table 1.2 (adapted from Newby et al., 2000), the role of the teacher will change from knowledge transmitter to that of learning facilitator, knowledge guide, knowledge navigator and co-learner with the student. The new role does not diminish the importance of the teacher but requires new knowledge and skills. Students will have greater responsibility for their own learning in this environment as they seek out, find, synthesize, and share their knowledge with others. ICTs provide powerful tools to support the shift to student-centred learning and the new roles of teachers and students.

Table 1.2 Changes in Student and Teacher Roles in Learner-Centred Environments

Changes in Teacher Role	
<i>A shift from:</i>	<i>A shift to:</i>
Knowledge transmitter, primary source of information, content expert, and source of all answers	Learning facilitator, collaborator, coach, mentor, knowledge navigator, and co-learner
Teacher controls and directs all aspects of learning	Teacher gives students more options and responsibilities for their own learning
Changes in Student Role	
<i>A shift from:</i>	<i>A shift to:</i>
Passive recipient of information	Active participant in the learning process
Reproducing knowledge	Producing and sharing knowledge, participating at times as expert
Learning as a solitary activity	Learning collaboratively with others

(Table adapted from one developed by Newby et al., 2000).

THEORIES SUPPORTING THE NEW VIEW OF THE LEARNING PROCESS

The new views of the learning process and the shift to student-centred learning have emerged based on cognitive learning research and the confluence of several theories that have informed our understanding of the nature and context of learning. Some of the most prominent theories include: sociocultural theory (based on Vygotsky's intersubjectiveness and Zone of Proximal Development), constructivism theory, self-regulated learning, situated cognition, cognitive apprenticeship, problem-based learning (Cognition and Technology Group at Vanderbilt), cognitive flexibility theory (Spiro et al, 1988), and distributed cognition (Salomon et al, 1993). Each of these theories is based on the same underlying assumptions that learners are active agents, purposefully seeking and constructing knowledge within a meaningful context. The learning environment that may be derived from this view of the learning process is shown in Figure 1.2.

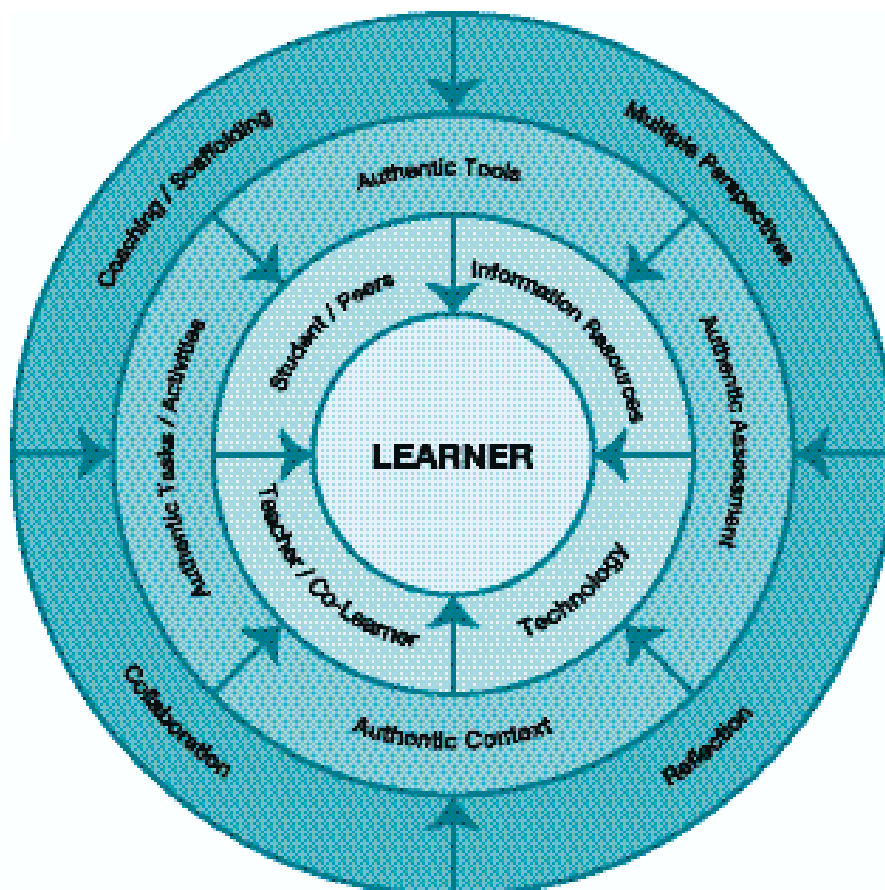


Figure 1.2 Student-Centred Learning Environment

The student-centred environment illustrated in this figure shows that the learner interacts with other students, the teacher, information resources, and technology. The learner engages in authentic tasks in authentic contexts using authentic tools and is assessed through authentic performance. The environment provides the learner with coaching and scaffolding in developing knowledge and skills. It provides a rich collaborative environment enabling the learner to consider diverse and multiple perspectives to address issues and solve problems. It also provides opportunities for the student to reflect on his or her learning.

Although the new learning environment can be created without the use of technology, it is clear that ICTs can provide powerful tools to help learners access vast knowledge resources, collaborate with others, consult with experts, share knowledge, and solve complex problems using cognitive tools. ICTs also provide learners with powerful new tools to represent their knowledge with text, images, graphics, and video.

The new view of the learning process is based on research that has emerged from theoretical frameworks related to human learning. Many reflect a constructivism view of the learning process. In this view, learners are active agents who engage in their own knowledge construction by integrating new information into their schema or mental structures. The learning process is seen as a process of "meaning-making" in socially, culturally, historically, and politically situated contexts. In a constructivism learning environment, students construct their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to new tasks, contexts and situations, and integrating the new knowledge gained with pre-existing intellectual constructs.

A constructivist environment involves developing learning communities comprised of students, teachers and experts who are engaged in authentic tasks in authentic contexts closely related to work done in the real world. A constructivist learning environment also provides opportunities for learners to experience multiple perspectives. Through discussion or debate, learners are able to see issues and problems from different points of view, to negotiate meaning, and develop shared understandings with others. The constructivist learning environment also emphasizes authentic assessment of learning rather than the traditional paper/pencil test. Some of the most influential theories that relate to new views of the learning process include:

Vygotsky's Sociocultural Theory

Vygotsky's sociocultural theory of human learning describes learning as a social process and the origination of human intelligence in society or culture. The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky believed everything is learned on two levels.

First, through interaction with others, and then integrated into the individual's mental structure.

Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (Vygotsky, 1978, p.57)

A second aspect of Vygotsky's theory is the idea that the potential for cognitive development is limited to a "zone of proximal development" (ZPD). This "zone" is the area of exploration for which the student is cognitively prepared, but requires help and social interaction to fully develop (Briner, 1999). A teacher or more experienced peer is able to provide the learner with "scaffolding" to support the student's evolving understanding of knowledge domains or development of complex skills. Collaborative learning, discourse, modelling, and scaffolding are strategies for supporting the intellectual knowledge and skills of learners and facilitating intentional learning.

The implications of Vygotsky theory are that learners should be provided with socially rich environments in which to explore knowledge domains with their fellow students, teachers and outside experts. ICTs can be used to support the learning environment by providing tools for discourse, discussions, collaborative writing, and problem-solving, and by providing online support systems to scaffold students' evolving understanding and cognitive growth.

Jean Piaget

Based on his research on the development of children's cognitive functions, Piaget's work is regarded by many as the founding principles of constructivist theory. He observed that learning occurs through adaptation to interactions with the environment. Disequilibrium (mental conflict which demands resolution) gives rise to Assimilation of a new experience, which is added to the existing knowledge of the learner, or to Accommodation, which is modification of existing understanding to provide for the new experience.

Specifically, Piaget posited that the existing cognitive structures of the learner determine how new information is perceived and processed. If the new information makes sense to the existing mental structure of the learner, then the new information item is incorporated into the structure (i.e., Assimilation). If, however, the data are very different from the existing mental structure of the learner, they are either rejected or transformed in ways so that it fits into the structure (i.e., Accommodation). The learner has an active role in constructing his or her own knowledge in both of these ideas. He observed that, as children assimilated new information into their existing mental structures, their ideas gained complexity and power, and their understanding of the world grew in richness and depth. These ideas are core concepts of the constructivism view of the learning process. (Jean Piaget Society, 2001)

Jerome Bruner

Similar to Piaget, Bruner emphasized that learning is an active process in which learners construct new ideas or concepts based upon their prior knowledge and experience. He identified three principles to guide the development of instruction. These include: (1) instruction must be concerned with the experiences and contexts that make the student willing and able to learn (readiness); (2) instruction must be structured so that the student can easily grasp it (spiral organization); and, (3) instruction should be designed to facilitate extrapolation and/or fill in the gaps (going beyond the information given).

Problem-Based Learning

The goals of problem-based learning (PBL) are to develop higher order thinking skills by providing students with authentic and complex problems and cases. This approach to learning provides a more authentic context for learning and engages students in authentic tasks. It is used frequently in fields such as engineering, medicine and architecture, and has been increasingly applied to K-12 settings. Through the process of working together, articulating theories, creating hypotheses, and critically discussing the ideas of others, students move to deeper levels of understanding of the problem. The self-directed learning strategies developed in PBL may help foster students' lifelong learning.

Anchored Instruction

Anchored instruction is an approach to designing instruction that is 'anchored' in a real world context, problem or situation. Technology has been used to help create 'real world' contexts and situations through the use of video. The video segments provide the context for the subsequent learning and instruction. (Bransford & Stein, 1993)

Distributed Cognition

Distributed cognition emphasizes that cognitive growth is fostered through interaction with others and involves dialogue and discourse, making private knowledge public and developing shared understandings. Tools for online collaboration have been designed to support collaborative knowledge construction and sharing in the classroom. (Oshima, Bereiter, and Scardamalia, 1995)

Cognitive Flexibility Theory

This theory asserts that people acquire knowledge in ill-structured domains by constructing multiple representations and linkages among knowledge units. It also notes that learners revisit the same concepts and principles in a variety of contexts. The theory is useful in understanding how knowledge is transferred in ill-structured knowledge domains. (Spiro et al., 1988)

Cognitive Apprenticeship

Cognitive apprenticeship is a term for the instructional process in which teachers or more experienced or knowledgeable peers provide 'scaffolds' to support learners' cognitive growth and development. Cognitive apprenticeship permits students to learn through their interactions, construct knowledge, and share knowledge-building experiences with the other members of the learning community. ICTs provide powerful new tools to support cognitive apprenticeships, enabling groups to share online workspaces to collaboratively develop artifacts and intellectual products. They also make possible tele-apprenticeships, in which an expert is able to work with or mentor a student who may be thousands of miles distant.

Situated Learning

Situated learning emphasizes the use of apprenticeship, coaching, collaboration, authentic contexts, tasks, activities and cognitive tools (Brown, Collins & Duguid, 1989). It occurs when students work on authentic tasks that take place in real-world settings (Winn, 1993). Learning is viewed as a function of the activity, context and culture in which it occurs, which contrasts with most classroom learning which is abstract and out of context (Lave, 1988). Situated cognition theory emphasizes providing an authentic context for the learner and encouraging social interaction and collaboration in the learning environment. Through collaborative problem solving, dialogue, and discussion students are able to develop deeper levels of understanding of a problem or knowledge domain.

Self-Regulated Learning

Self-regulated learners are those who are aware of their own knowledge and understandings, i.e., what they know and what they do not know or need to understand. It combines self-observation, self-judgment, and self-reaction. Self-regulation plays a crucial role in all phases of learning and has the potential to increase the meaningfulness of students' classroom learning (Schoenfeld, 1987). ICT tools can be used to make students' tacit knowledge public and to help them develop metacognitive skills and become more reflective and self-regulated learners (Hsiao, 1999).

These theories that undergird the new views of the learning process help shape the new pedagogies for learning. Ultimately, the power of ICTs will be determined by the ability of teachers to use the new tools for learning to create rich, new, and engaging learning environments for their students. The UNESCO World Education Report (1998) notes that:

There are indications that the new technologies could have radical implications for conventional teaching and learning processes. It notes that, in reconfiguring how teachers and learners gain access to knowledge and information, the new technologies challenge conventional conceptions of both teaching and learning materials, and teaching and learning methods and approaches.

The challenge for ICTs in Teacher Education is to assure that the new generation of teachers, as well as current teachers, are well prepared to use new learning methods, processes and materials with the new ICT tools for learning. The following sections provide a road map to help teacher education institutions meet the challenge.

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II.

THE RATIONALE AND FRAMEWORK FOR ICTs AND TEACHER EDUCATION

This section provides a rationale and framework for the process of training teachers and their associates to adopt ICTs in education. It draws upon the new views of the learning process outlined earlier and describes appropriate approaches to professional development and organizational change. A detailed framework and objectives for the teacher education ICT curriculum are provided in the following sections. Models and frameworks for change are discussed and illustrated toward the end of this document.

In many of the countries targeted with this curriculum, ICTs are in the early stages of development in commerce, industry, and particularly, in society. Communities and regions may have very limited resources, so it is important to undertake a careful analysis using an ethnographic approach to develop an organic strategy for the growth and development of education and teacher education that takes advantage of ICTs. The vision is not simply of ICTs, but of better education facilitated through the adoption and promotion of ICTs. An explanation of this vision is attempted in a limited way in the illustration provided in the framework section.

The Society for Information Technology and Teacher Education has identified basic principles for development of effective ICT teacher education (SITE, 2002). These are:

- *Technology should be infused into the entire teacher education programme.* Throughout their teacher education experience, students should learn about and with technology and how to incorporate it into their own teaching. Restricting technology experiences to a single course or to a

single area of teacher education, such as methods courses, will not prepare students to be technology-using teachers. Pre-service teacher education students should learn about a wide range of educational technologies across their professional preparation, from introductory and foundations courses to student teaching and professional development experiences.

- *Technology should be introduced in context.* Teaching pre-service students basic computer literacy-the traditional operating system, word processor, spreadsheet, database, and telecommunications topics is not enough. As with any profession, there is a level of literacy beyond general computer literacy. This more specific or professional literacy involves learning to use technology to foster the educational growth of students. Professional literacy is best learned in context. Pre-service students should learn many uses of technology because they are integrated into their coursework and field experiences. They should see their professors and mentor teachers model innovative uses of technology; they should use it in their own learning, and they should explore creative uses of technology in their teaching. Teacher educators, content specialists, and mentor teachers should expose pre-service teachers to regular and pervasive modelling of technology and provide opportunities for them to teach with technology in K-12 classrooms.
- *Students should experience innovative technology-supported learning environments in their teacher education programme.* Technology can be used to support traditional forms of learning as well as to transform learning. A PowerPoint presentation, for example, can enhance a traditional lecture, but it does not necessarily transform the learning experience. On the other hand, using multimedia cases to teach topics that have previously been addressed through lectures may well be an example of a learning experience transformed by technology. Students should experience both types of uses of technology in their programme; however, the brightest promise of technology in education is as a support for new, innovative, and creative forms of teaching and learning (SITE, 2002).

While the proposed ICT in teacher education curriculum should aspire to no less, the trajectory of the development for countries, regions, and organizations should be appropriate to the level of resources, including expertise, leadership, and ICTs themselves. A widespread approach to reach a scattered population of teachers and organizations that are ready to move a small step forward with very limited resources may be helpful at an early

stage. Creating centres of transferable excellent practice that encourage 'reference site' visits, and mentoring teachers in other locations, are also approaches that may be effective. This section will review the stages of teacher education and provide examples of approaches for teacher education in ICTs and through ICTs.

STAGES OF TEACHER EDUCATION

Approaches to the professional development of teachers must be dependent on context and culture. Since there are a variety of approaches, an overview of the many stages in which teachers receive teacher education may prove helpful. Professional development to incorporate ICTs into teaching and learning is an ongoing process and should not be thought of as one 'injection' of training. Teachers need to update their knowledge and skills as the school curriculum and technologies change. Individuals develop in stages and mature over time. Personal development must be accompanied by organizational development in schools, training centres, and universities.

In many regions, teachers engage in preparation before they start teaching in schools, a stage referred to in this document as pre-service teacher education. When pre-service teachers begin to teach they may be given additional support to handle the complexity of their work for the first to third years of their career. This stage of professional development is called induction. The induction stage demands a great deal of effort and commitment, and research in developed countries reveals that around 30% of teachers may drop out during this time. Some teachers do not have the benefit of a preparatory course and must learn while teaching in schools, a condition referred to as on-the-job training. Such training is probably carried out within the school, perhaps with the teacher receiving some release from normal duties. Teacher education is an ongoing process of lifelong learning. The final stage, consisting of additional professional development, is called in-service teacher education.

It is important to note that some very strong models of teacher education provide simultaneous professional development for more than one group. For example, pre-service preparation can be aligned with in-service teacher education. A practising teacher may work with a pre-service teacher education student on an innovative educational project. This not only increases the research potential of the in-service teacher, but the pre-service teacher also experiences role modelling and, as a result, may have an easier transition into teaching.

Professional learning communities allow teachers to support the professional development of colleagues and receive support themselves. ICTs have increased the access to and reach of such professional associations. Mentorship can be fostered across geographic distances and supported by synchronous and asynchronous interaction. Professional development may also be enhanced by public or private partnerships with the community. Such partnerships may be particularly appropriate for professional development related to ICTs, with financial and technical support contributed by ICT companies, such as the Intel *Teach to the Future* Programme, or by local communities.

The professional development of teacher educators is also essential. Unless teacher educators model effective use of technology in their own classes, it will not be possible to prepare a new generation of teachers who effectively use the new tools for learning. It is also important to consider the question of who may teach. With ICTs, students often become teachers, using the processes of peer tutoring or reciprocal mentoring. Indeed, a teacher may facilitate learning by reversing the teaching-learning roles, with students acting as expert learners who model the learning process. ICTs provide extensive opportunities for this to occur in ways that can increase the self-esteem, motivation, and engagement of students. Teachers need encouragement to adopt such strategies rather than to feel ashamed to be taught by young learners. Members of the community also may become teachers, or at least invited experts. ICTs extend the range of such opportunities and provide access to extensive relevant supporting materials. The teacher's role changes to manager and facilitator in many of these situations as the teacher helps the expert communicate with the learners and scaffolds the learning process. The teacher also acquires professional development by learning from the expert.

The focus of professional development should also be expanded to those who work with teachers: the classroom assistants, school leaders, and members of regional and national organizations for curriculum and professional development. A common vision for the role of ICTs in education is important for its success. Teachers may find it impossible to incorporate ICTs into their work without support and encouragement from colleagues, parents, and leaders. To bring this about, these community members may also need professional development, along with the teachers.

Teacher Education in ICTs

The most obvious technique for professional development for teachers is to provide courses in basic ICTs knowledge and skills, delivered by experts in national

and regional centres. These types of courses, taught at training centres or universities with a syllabus set by regional or national agencies, have been a common practice in many countries. However, this approach has had limited success without follow-on training and support, as compared to effective use of ICTs by trained teachers. Similarly, courses for teachers in particular software and hardware applications are difficult to implement in a way that results in use of these applications in classroom instruction or other professional practices without additional support. As noted in an earlier section, the development of ICTs does not improve education if the focus is on ICTs. The vision must focus on what ICTs can do to improve education.

A more successful approach is to provide on-site training in schools that addresses the concerns of individual teachers and is supported by leadership within the school. Two examples of this approach follow:

- In a programme in the UK, advisory teachers were trained and given ICT resources and an opportunity to work alongside classroom teachers. The advisory teachers were able to see the context in which the teachers worked and, with the teachers, were able to develop appropriate deployment of ICTs for curriculum use and promote the successful organization of resources in the school and the region. This approach, however, is resource-intensive and is not feasible for many schools.
- In a recent project at the University of Virginia, teacher educators assigned project work for pre-service teachers requiring innovative use of ICTs, and at the same time, provided in-service ICT training for the teachers in the schools where the pre-service teachers taught. The teacher educators coordinated these activities with the school technology plans. In this model-although it, too, is resource intensivethe ongoing partnership between the university and the school provides for capacity building.

Over the last decade, many countries that included ICTs in education were slow to also include it in teacher education. Only recently have national agencies begun to realize the importance of educating teachers at the beginning of their careers. Younger people are more likely to be familiar with ICTs, to be adaptable, and to not yet have formed habitual modes of instruction that are more difficult to change with more experienced teachers. It is in the pre-service stage that they are most open to learning how to infuse technology into instruction. Based on their long experiences with traditional modes of learning, teacher educators may find it challenging to incorporate ICTs into their own instructional practices. They may also lack experience in developing the com-

plex partnerships between higher education and schools that facilitate technology-rich contexts for training student teachers. To bring this about, it is usually necessary that the faculty be held accountable to standards and that the institution provides both incentives and resources to support technology-rich programmes and initiatives.

One approach that encourages collaboration between the teacher preparation programme and the community is the formation of computer clubs for students interested in computers and education. This approach was used successfully in Russia and works well where computing resources are limited. Care must be taken, however to ensure that the emphasis is on education rather than on games or competitions. Peer tutoring models are very effective in club settings and may develop into reciprocal mentoring with teachers in which the students provide ICT training for peers and teachers and the teachers mentor the tutors' developing skills as teachers. Peer tutoring is a relatively common approach in classrooms of cultures around the world. This approach is effective even when teachers have little ICT skill and knowledge. Parents and other community members may also serve as teachers, tutors, and co-learners, and the whole community may benefit economically because of an increase in the ICT skills among diverse members of the community. GenY is a peer tutoring approach that has been successful in many places, including the Caribbean and the USA.

Teacher Education through ICTs

ICTs may also support effective professional development of teachers in to how to use ICTs. A limited initiative to integrate an innovative approach to teaching and learning with one new technology for a large population of teachers can be an important early step for a nationwide strategy. The UNESCO document, *Teacher Education Through Distance Learning* (UNESCO, 2001), describes interactive radio, a professional development model in which radio programmes provide daily half-hour lessons introducing pupils to English through active learning experiences with native English speakers. The radio programmes reach 11,000 teachers across South Africa. The initiative is successful in developing teachers' pedagogical, language, and technology skills. Much of this success is due to the appropriateness of the technology choice for South Africa.

When ICTs are introduced into a community, they may address multiple goals and may expand our conception of education. For example, the Drik project in Bangladesh started as an ecology project. The goal was to

plant trees and educate the local population in how to care for them. The project brought a single computer with an Internet link into the community. The introduction of this computer, coupled with peer tutoring, resulted in the development of considerable ICT skills in the young people of the region, and today the school is a centre for ICT services both locally and globally (including the USA). Although the teachers were not the leaders in this initiative, they learned to adopt ICTs and incorporate them into the curriculum and administration of their school. This extension of the 'business' of the school beyond traditional education tasks is not unusual for schools in economically depressed communities that learn the value of technology in enhancing vocational opportunities.

MirandaNet is an important example of teachers who use ICTs to mentor each other and to establish new communities connected through the Internet. The brainchild of an active teacher educator and consultant, MirandaNet is supported by partners in business and commerce. Originating in the UK, MirandaNet has spawned related communities in the Czech Republic and Chile, and negotiations are underway for a Chinese MirandaNet. Further details of this project are provided in a case study in Section IV.

A final example of in-service teacher education is relevant to countries in transition, where development of skills, expertise, and resources have been disrupted. The MATEN European project provided expertise to a Ukrainian Centre which created a course for English teachers who wanted to teach through the Internet (MATEN, 2002]. The technology focus was on online learning and teaching. Challenges included retention of the very limited population of English teacher educators and their access to reliable Internet workstations. Despite this, the enthusiasm of a small percentage of teachers over a vast area of the former Soviet Union did result in ICT teacher education for an important cadre of teachers. The situation may improve, as technology facilities improve and curriculum resources increase due to grants from European countries and the USA, especially for teachers of English. A longer description of this project is provided within section IV. The important point to note here, in relation to professional development, is that transfer-ability of the majority of these materials remains questionable because they were developed for classrooms in very different cultures, many of which are considered extremely rich in resources by developing countries' standards. The materials require adaptation and customization to meet the needs of the unique culture, context, and educational systems of UNESCO Member States.

A FRAMEWORK FOR INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) IN TEACHER EDUCATION

Introduction

In planning for the infusion of ICTs into teacher preparation programmes, several factors important to a programme's success must be considered. This section provides a holistic framework to assist in designing the integration of information and communication technologies (ICTs) into teacher education. The framework is coherent with the context provided by today's society and reflects more recent understandings of the nature of learning, including aspects of learning communities during the school years and beyond into life-long learning. The holistic framework will help teacher educators and administrators consider the cultural and educational system context, technology resources, and other factors that are important in planning the integration of technology into the pre-service curriculum. Limited technology resources and conditions of rapid change in educational, economic and political systems challenge many contexts of this curriculum. In some regions, the shortage of teachers, teacher educators, facilities and standards has been chronic for years and has reached crisis proportions. Access to ICT resources may also be quite limited. Within this document, ICTs should be broadly defined as including 'interactive radio' and multiple media including TV, as well as computers and hand-held electronic devices.

A generic ICT in teacher education curriculum framework is provided in Figure 2.1. The encompassing oval underscores that the framework should be interpreted as a whole. To select parts or to simply copy the framework in rote fashion without taking care to understand the synergy of the whole would be a mistake. As the term synergy implies, the whole is more than the sum of its parts. For example, an approach resulting from informed leadership and vision is essential for ensuring that all the components of planning and implementing a technology integration plan are present and that they support one another.

The framework was designed by representatives of international projects to assist policy makers, course developers, teacher educators, and other professionals who are charged with developing the use of information and communication technologies (ICT) in teacher education. The model will help assure that national and local infrastructure, culture and context, among other factors, will be considered in designing new curricula, and that curricula will be kept up to date, as new developments are forged in education and ICTs.

Figure 2.1 shows the curriculum framework is comprised of four clusters of competencies encircled by four supportive themes. The curriculum framework also suggests that each teacher is allowed to interpret the framework within his or her context and personal approach to pedagogy, which is always related to the subject discipline or content area, rather than to the technology itself. The four themes that bind the curriculum as a whole are described briefly below, followed by descriptions of the four core competencies.

Finally, the core curriculum is illustrated with a hypothetical example that demonstrates how the framework may be applied to a specific situation. Further illustrations drawn from the collaborative development of teacher education across seven countries in Europe may be found online in the T3 Showcase at <http://telematics.ex.ac.uk/T3> (Davis et al, 1999) and from projects in the USA in the PT3 national web site at <http://www.pt3.org>.

Four Themes

Context and Culture identifies the culture and other contextual factors that must be considered in infusing technology into teacher education curriculum. It includes the use of technology in culturally appropriate ways and the development of respect for multiple cultures and contexts, which need to be taught and modelled by teachers. *Leadership and Vision* are essential for the successful planning and implementation of technology into teacher education and require both leadership and support from the administration of the teacher education institution. *Lifelong Learning* acknowledges that learning does not stop after school. In common with the other themes, it is important that teachers and teacher preparation faculty model lifelong learning as a key part of implementation, and as an ongoing commitment to ICTs in teacher education. *Planning and Management of Change* is the final theme, born of today's context and accelerated by technology itself. It signifies the importance of careful planning and effective management of the change process.

These themes may be understood as a strategic combination of approaches that help teacher educators develop the four core competencies. The core competencies may be seen as clusters of objectives that are critical for successful use of ICTs as tools for learning.

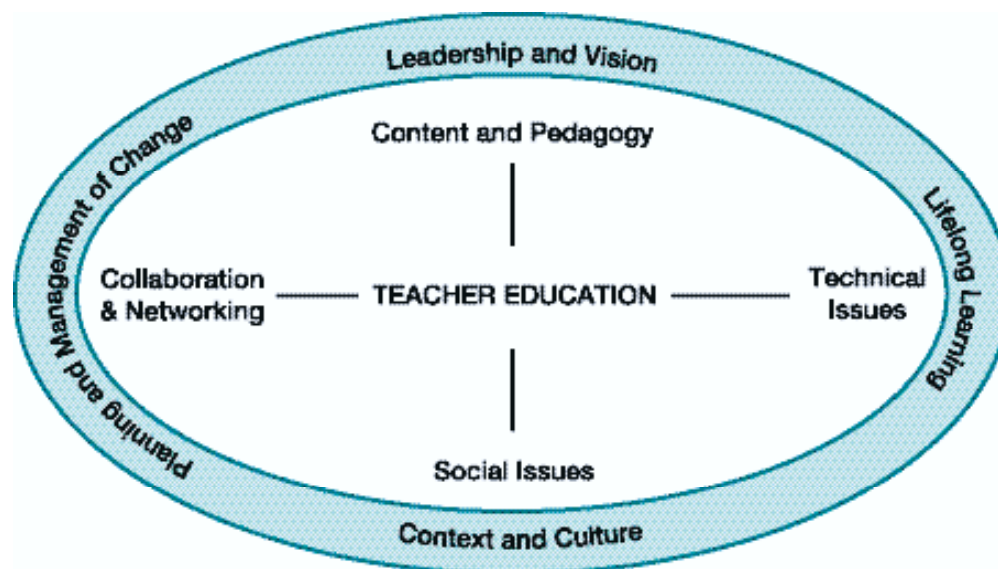


Figure 2.1 A Framework for ICTs in Teacher Education

Four Competencies

The ICT competencies are organized into four groups. *Pedagogy* is focused on teachers' instructional practices and knowledge of the curriculum and requires that they develop applications within their disciplines that make effective use of ICTs to support and extend teaching and learning. *Collaboration and Networking* acknowledges that the communicative potential of ICTs to extend learning beyond the classroom walls and the implications for teachers development of new knowledge and skills. Technology brings with it new rights and responsibilities, including equitable access to technology resources, care for individual health, and respect for intellectual property included within the *Social Issues* aspect of ICT competence. Finally, *Technical Issues* is an aspect of the Lifelong Learning theme through which teachers update skills with hardware and software as new generations of technology emerge.

As a final reminder of the holistic nature of this curriculum, the model illustrates the interdependence of the themes and competencies – all themes interacting with all competencies. The following is a description of the four competencies.

Pedagogy

The most important aspect of infusing technology in the curriculum is pedagogy. When implementing the pedagogical competencies for infusing tech-

nology, the local context and the individual approach of the teacher linked with that of their subject discipline must be paramount. Teachers move through stages as they adopt ICTs. Initially, the teacher adopting technology applies it simply as a substitute for current teaching practice where technology is not used (e.g., teacher lecture becomes electronic presentation supporting lecture, students writing papers by hand become students writing papers using a word processor, course syllabus on paper becomes course syllabus online). The adaptation of ICTs by teachers should (and does) challenge and support changes in teaching practice, building upon individual pedagogic expertise. As teachers' pedagogical practices with new technologies continue to develop, and organizational support and access to ICTs grow, it becomes possible to move beyond the adaptation of ICT applications that fit with existing practice. Transformation of the educational process will start to emerge and may move toward more student-centred learning environments as shown in Figure 1.2.

In summary, as professional teachers educators continually develop their pedagogical use of ICTs to support learning, teaching, and curriculum development, including assessment of learners and the evaluation of teaching, they will:

- demonstrate understanding of the opportunities and implications of the uses of ICTs for learning and teaching in the curriculum context;
- plan, implement, and manage learning and teaching in open and flexible learning environments;
- assess and evaluate learning and teaching in open and flexible learning environments.

Collaboration and Networking

ICTs provide powerful new tools to support communication between learning groups and beyond classrooms. The teacher's role expands to that of a facilitator of collaboration and networking with local and global communities. The expansion of the learning community beyond the classroom also requires respect for diversity, including inter-cultural education, and equitable access to electronic learning resources. There is growing evidence that communities learn through collaborative activities that reflect diverse cultures in authentic projects that serve society. Both local and global understandings can be enhanced using ICTs, as illustrated in the fictional example of School X later in this section. The development of teachers' competencies in networking and collaboration are therefore essential to ICTs in

education. Through collaboration and networking, professional teachers promote democratic learning within the classroom and draw upon expertise both locally and globally. In this process, they will:

- demonstrate a critical understanding of the added value of learning networks and collaboration within and between communities and countries;
- participate effectively in open and flexible learning environments as a learner and as a teacher;
- create or develop learning networks that bring added value to the education profession and society (locally and globally); and
- widen access and provide learning opportunities to all diverse members of the community, including those with special needs.

Social and Health Issues

The power to access information and communication technologies brings increased responsibilities for everyone. Legal and moral codes need to be extended to respect the intellectual property of freely accessible information. Copyright applies to web resources, too, regardless of the ability of the user to purchase the rights. This respect can be modelled in classroom practice with students from an early stage. The challenges faced by society, locally and globally, by adoption of technology should become part of the curriculum in a way that involves learners and helps them to develop an effective voice in the debates. Health issues of ICTs also need to be addressed. For example, prolonged engagement with ICTs (including screens and keyboards) requires appropriate support for the body, especially the hands and back. Similarly, hazards of electricity and other power sources require care and the modelling of safe practice. The technology standards for students and teachers from the International Society for Technology in Education (ISTE) offer guidelines for social issues, under the topic of social, ethical, legal, and human guidelines relating to the responsible use of technology. The ISTE standards may be found at <http://cnets.iste.org>.

In summary, professional teachers need to understand social and health issues surrounding ICTs and apply that understanding in their practice. Specifically, they need to:

- understand and apply the legal and moral codes of practice, including copyright and respect for intellectual property;
- reflect upon and lead discussion of the impact of new technology on society, locally and globally;
and
- plan and promote healthy use of ICTs, including seating, light, sound, and related energy sources (including electricity and radio signals).

Technical Issues

Technical issues regarding integration of ICTs into the curriculum include the technical competencies and provision of both technical infrastructure and technical support for technology use throughout the curriculum. Technical competencies of the individual are perhaps the most obvious but perhaps the least important in the long-term because use of technology should ultimately become transparent. When technology is robust and used competently, it moves from the foreground to the background and remains essential. This is similar to the process of gaining any new skillset, such as riding a bicycle. Each new skill must be consciously attended to and practiced until it becomes an automatic response. Competent bike riders do not focus on balance and the pedals of the bike, they focus on navigation and safety. However, we do recognize that in many contexts, the lack of technology competence, infrastructure, and technical support can create barriers to access and reliability resulting in diminished support for the curriculum. Additional technical support or training is therefore advised, depending on local circumstances.

Simply providing the technology for learners and teachers is not enough. The type and level of access is also important. ICTs will improve learning very little if teachers and students have only rare and occasional access to the tools for learning. Reasonable access to ICTs has been shown to be important for the acquisition of competence with hardware and software, especially for teachers. For example, provision of portable computers is an important strategy for ICTs teacher education. Teachers with portable computers can use them for both teaching in school and for other professional activities elsewhere.

In summary, professional teachers, provided with reliable technology infrastructure and technical assistance, demonstrate continual growth in their skill

with ICTs and knowledge of their current and emerging applications within education and local and global society. Specifically they are able to:

- use and select from a range of ICT resources to enhance personal and professional effectiveness;
and
- willingly update skills and knowledge in the light of new developments.

The following hypothetical description of School X provides one example of the application of the framework in designing ICTs in education and teacher education in the context of limited resources.



Figure 2.2 School X Experience

The focus of this illustration is the second stage of implementation of the curriculum framework into a context with limited resources within education. Today School X has little technology: only one personal computer with a floppy disk drive, a printer and a colour screen in the school office. The local manufacturing company has recently proudly provided the school with six hand-held graphic calculators with sensors to measure light and acid levels. School X also

has a TV with videotape player, a radio with amplifier, a tape recorder and a camera. There is a very small library. In the small town nearby there is a cyber cafe in which the population plays games, surfs the Internet and sends email to relations who work some distance away. Telephones are rarely in homes, but a shop sells time on phones and helps people send faxes and emails. Such shops also provide relatively cheap photocopying for businesses, and occasionally, for the school.

The associated teacher training centre has a range of resources and is working to support implementation of ICTs within regional curriculum standards. It plans to involve leaders within its target schools in the preparation of materials to support good practice. Target schools were chosen to represent the diversity in the region and based on their readiness for innovation with ICTs and pedagogy. Two leading teachers in each school were given a laptop computer with a printer and software to assist in publishing materials.

One young newly qualified teacher in School X has competence with ICTs and, as part of her course of teacher education in Hong Kong, worked on a class Newspaper Project. She has planned, with support from her mentor and head teacher, to stop her class curriculum for a day so that her class and that of her mentor can work under her leadership to produce a School Newspaper. Together the two teachers have developed plans for aspects of the entire core curriculum: language, mathematics, social studies and science. Work in the core subjects for half of the term provides the basis for one or more group's knowledge. Their students are becoming accustomed to project work in addition to the more traditional whole class teaching. Each team within the two classes has their own section of the Newspaper to prepare. There is also an editorial team to put the sections of the paper together on the computer, and a marketing team, who have been 'selling' advertising space and finding out about potential readership among families and friends of the school, including the local newspaper company.

The newspaper copy will be produced on the computer using very limited publishing software (a word processor), so scissors and glue must also be part of the layout strategy. The printing press will be the photocopier of the local copy shop. The pupils will sell copies of their newspaper at the school gates at the end of the day, so the press deadline and the audience are real and very pressing!

Each group has been working to produce a story typed and edited on the computer. They may also have an illustration, using a photo, graph, or piece

of artwork. For example, the science group has written an article on the levels of acidity in several locations of the town over the last week. The graphing calculator and its sensors permitted them to work authentically, like scientists, taking many measures to investigate their questions. They also searched the Internet to find that there are others worried about the rapidly increasing levels of acidity.

The social studies group will produce more than one article. They have gathered oral histories and, in addition to their written story of a tragic event that occurred nearby 20 years ago, they have collected a set of audio-taped interviews and photographs that will be stored in the school library for classes who come after them. This social studies topic was started with a visit by one of the parents, who told stories about the tragic day and what led up to it. She brought a newspaper from that time and a damaged article of clothing. These activities are part of the changes in the pedagogic approach to the history curriculum, which emphasizes the critical use of artifacts to explore concepts and issues.

The two classes have also discussed the place of newspapers and new technology in society today. The two teachers will hold a debriefing session later in the term with the students to help them reflect and build upon this intense educational experience.

This Newspaper Day is an example of good practice with ICTs that will be gathered for the region. This is part of the strategy to build capacity for ICTs in teacher education in the surrounding communities. The local centre for teacher training is sending observers with video cameras to record the activity and interviews with teachers, students, parents, and friends. They will also gather artifacts, including the final Newspaper, the groups' drafts, and the examples used by the teacher to motivate and direct the student work. This will be edited into a pack of materials available for loan to district schools and advertised on the Internet in the local languages. It will be launched with a two-day training event in the regional teacher-training centre. The originating teachers will be guests of honour who will answer questions about the challenges and issues that arise when developing ICTs across the curriculum in their region. All target schools to be included in the next group will be represented. There will also be discussion of the potential of a Newspaper Day competition to stimulate more activity, with sponsorship and prizes from the regional press association.

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III.

ICTs IN TEACHER EDUCATION CURRICULUM PLANNING AND DEVELOPMENT

INTRODUCTION

The *Framework for Information and Communication Technologies (ICTs) in Teacher Education* in Section II identifies four themes and competencies to consider when planning for the infusion of ICTs into teacher preparation programmes. Together they represent a complex set of components to consider when planning for integration of ICTs into teacher education programmes. Consequently, professional associations, countries, states, or universities often collaborate within their larger educational community to establish ICT standards and guidelines that describe the knowledge, skills, and dispositions teacher candidates are expected to demonstrate upon completion of their teacher education programmes. These accepted standards not only provide guidance to universities when developing plans for infusion of technology into their teacher education programmes, but also establish a measure of consistency among teacher education programmes within a region. Many regions and countries in Europe, the USA, Asia, and Australia have adopted a set of ICT standards for pre-service and in-service teacher education.

A vision for ICTs in Education often precedes the development of standards. One illustrative example is the Singapore government's Master Plan for Information Technology (IT) in Education, launched in 1997 to usher in a new era of educational development. It specified three goals:

- To train every teacher in purposeful use of IT for teaching;

- To equip teachers with core skills in teaching with IT; and
- To involve institutions of higher education and industry partners in schools. (Jung, 2000, p.38)

In Singapore, the National Institute for Education (NIE) is the only provider of pre-service teacher education. In her review of pre-service teacher training in ICTs, Jung (2000) describes keys to the success of ICTs integration. NIE's approach includes several notable strategies.

- It provides a short foundation course that focuses on hands-on IT experience as the initial stage of pre-service training. (Such a course should focus on applying IT skills to achieve pedagogical objectives, rather than teaching IT skills in isolation.)
- It provides more advanced IT courses as electives for students who need or want to develop more advanced IT-based pedagogical skills.
- It integrates IT components into all of the subject matter areas such as math, social studies, English, and so on, so that students have a role-model for IT-integrated teaching and learning.
- It designs IT-integrated courses in such a way that students have the opportunity to produce IT-based instructional materials themselves and share outcomes of the course with others. (Jung, 2000)

STANDARDS FOR GUIDING IMPLEMENTATION OF ICTs IN TEACHER EDUCATION

This section describes a set of standards developed in the USA and contrasts it with approaches in other countries, particularly within Europe.

USA

The International Society for Technology in Education (ISTE) has developed a set of standards to provide guidance and consistency to programmes. These standards are used widely in several countries and serve as the National Educational Technology Standards (NETS) for the United States of America. The ISTE NETS for Students (NETS*S) describe what students from pre-school to grade twelve should know about and be able to do with technology. The student standards provide a basis for the development of technology standards for teachers (NETS*T) and technology standards for

educational administrators (NETS*A). These sets of standards provide states, districts, schools, and teacher education institutions the foundations upon which the integration of technology in their programmes can be built. Other countries and regions that have developed, adopted, or adapted national or regional standards include: Australia, China, Ireland, Latin America and the United Kingdom.

Whether a university is establishing a new teacher education programme specializing in ICT leadership or redesigning an existing teacher education programme into which technology is to be woven, ICT standards can provide a substantial foundation for the planning process. For example, the ISTE NETS for Teachers can provide guidance in the planning process for addressing all four of the major components in the *Framework for ICTs in Teacher Education* provided in Section II of this document. ISTE's performance-based standards describe what the teacher candidates should do to demonstrate that they are competent users of ICTs and that they can facilitate competent use of technology by their students. Table 3.1, The ISTE National Educational Technology Standards for Teachers, provides standards and performance indicators describing what pre-service teachers should know about and be able to do with technology upon completion of their teacher preparation programme.

The four key components providing the framework for technology competence can be supported through implementation of the six ISTE standards. Standard I addresses technical competence. Standards II, III, and IV address preparation, implementation, and assessment supporting content learning, effective pedagogical strategies, and informative performance assessment practices. Standard V speaks to the use of ICT tools for a variety of professional, communication, and collaborative activities among teachers. Standard VI addresses the social, ethical, legal, and human issues inherent when technology expands communications and learning opportunities globally.

The rapid infusion of technology into schools requires a new generation of leaders who are able to use the new tools to enhance their own productivity and decision-making activities and who understand the importance of integrating technology into the learning process. Leadership is often the most important factor in the successful integration of ICTs into the school's instructional practices and curriculum. Research has shown that without effective and supportive leadership, changes in the teaching-learning process and widespread, effective uses of technology in learning are not likely to occur.

To encourage educators to prepare for positions of leadership in ICTs, the ISTE Accreditation and Professional Standards Committee has developed accreditation standards for teacher preparation programmes for specialization in ICTs. The technology specialization guidelines have been adopted by the National Council for Accreditation of Teacher Education (NCATE) and are currently used in evaluation of teacher preparation programmes for accreditation.

Table 3.1. The ISTE National Educational Technology Standards for Teachers

All classroom teachers should be prepared to meet the following standards and performance indicators.	
I.	Technology Operations and Concepts: Teachers demonstrate a sound understanding of technology operations and concepts. Teachers:
A.	demonstrate introductory knowledge, skills, and understanding of concepts related to technology (as described in the ISTE National Educational Technology Standards for Students URL: http://cnets.iste.org);
B.	demonstrate continual growth in technology knowledge and skills to stay abreast of current and emerging technologies.
II.	Planning and Designing Learning Environments and Experiences: Teachers plan and design effective learning environments and experiences supported by technology. Teachers:
A.	design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners;
B.	apply current research on teaching and learning with technology when planning learning environments and experiences;
C.	identify and locate technology resources and evaluate them for accuracy and suitability;
D.	plan for the management of technology resources within the context of learning activities;
E.	plan strategies to manage student learning in a technology-enhanced environment.
III.	Teaching, Learning, and the Curriculum: Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning. Teachers:
A.	facilitate technology-enhanced experiences that address content standards and student technology standards;
B.	use technology to support learner-centred strategies that address the diverse needs of students;
C.	apply technology to develop students' higher order skills and creativity;
D.	manage student learning activities in a technology-enhanced environment.
IV.	Assessment and Evaluation: Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies. Teachers:
A.	apply technology in assessing student learning of subject matter using a variety of assessment techniques;
B.	use technology resources to collect and analyze data, interpret results, and communicate findings to improve instructional practice and maximize student learning;
C.	apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.

- V. Productivity and Professional Practice: Teachers use technology to enhance their productivity and professional practice. Teachers:
- A. use technology resources to engage in ongoing professional development and lifelong learning;
 - B. continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology in support of student learning;
 - C. apply technology to increase productivity;
use technology to communicate and collaborate with peers, parents, and the larger community in order to nurture student learning.
- VI. Social, Ethical, Legal, and Human Issues: Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply that understanding in practice. Teachers:
- A. model and teach legal and ethical practice related to technology use;
 - B. apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.
 - C. identify and use technology resources that affirm diversity;
 - D. promote safe and healthy use of technology resources;
 - E. facilitate equitable access to technology resources for all students.

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ISTE/NCATE accreditation standards for programmes in educational computing and technology include:

- ISTE/NCATE Standards for Educational Computing and Technology Facilitation-initial endorsement programme to prepare technology literacy teachers or campus leaders who support teachers' integration of technology in the classrooms;
- ISTE/NCATE Standards for Educational Computing and Technology Leadership-advanced programme to prepare district, state, or regional educational technology coordinators;
and
- ISTE/NCATE Educational Computing and Technology Secondary Computer Science Education Standards-initial endorsement or degree programmes to prepare secondary teachers of computer science. (ISTE, 2002)

The documented importance of a shared vision among the multiple levels of an organization indicates the need for technology standards for education administrators. ISTE managed the development of Technology Standards for School Administrators (TSSA), which identify performance standards for the

technology skills, knowledge, and dispositions of education administrators. The TSSA Collaborative has developed standards for school administrators that include specific indicators for the superintendent, school administrator, and district level administrator. School administrators must understand and support the use of technology at all levels so that they can work collaboratively with universities on appropriate field placements and help new teachers incorporate technology into classroom instruction.

Europe

Many countries in Europe have official recommendations for ICT-related skills for future and practicing teachers. Eurydice, the information network on education in Europe, annually publishes *Basic Indicators on the Incorporation of ICT into European Education Systems* (Eurydice, 2001). According to this report, some countries state only that teaching about ICTs is compulsory, without specifying what skills should be developed and what content should be included. In the majority of European countries, as much importance is attached to the teachers' personal command of ICTs as to mastery of ICTs for teaching purposes. Recommended most frequently in lower secondary education are the use of word processing and data processing software. In France, the Netherlands and the United Kingdom, the content of training is determined to some extent by the mandatory standards. In the UK, there is also a detailed curriculum for the use of ICTs in teaching specific subjects.

Countries and regions adopting standards for the first time may wish to do so in stages. This was the strategy taken by the UK, which currently has the most detailed standards of any country in Europe. The standards were first imposed with a relatively simple section within the mandatory standards (criteria for government approval of courses) for pre-service teachers in 1989. This section states:

On completion of their course, all students should be able to select and make appropriate use of a range of equipment and resources to promote learning. In particular, all courses should contain compulsory and clearly identifiable elements that enable students to make effective use of information technology (IT) in the classroom and provide a sound basis for their subsequent development in the field. They should be trained to:

- make confident personal use of a range of software packages and IT devices appropriate to their subject specialization and age range;

- review critically the relevance of software packages and IT devices to their subject specialization and age range and judge the potential value of these in classroom use;
- make constructive use of IT in their teaching and in particular prepare and put into effect schemes of work incorporating appropriate uses of IT;
and
- evaluate the ways in which the use of IT changes the nature of teaching and learning. (Department for Education and Science, 1989)

Some years later the UK government developed highly detailed standards for pre-service teacher education and then also developed a nation-wide strategy to train all teachers in pedagogical use of ICTs. The detailed curriculum has the following expected outcomes for teachers. Teachers should know:

- when, when not and how to use ICTs in teaching their subject;
- how ICTs can be used for teaching the whole class;
- how ICTs can be used when planning, including the use of ICTs for lesson preparation and the choice and organization of ICT resources;
- how to assess pupils' work when ICTs have been used;
and
- how ICTs can be used to keep up-to-date, share best practice and reduce bureaucracy. (Teacher Training Agency, 2001)

The curriculum is detailed in two sections with eighteen competencies. Each competency has between 0 and 8 statements. The complete curriculum is available online. The Teacher Training Agency also developed a CD to help teachers analyze their own training needs. A complementary outcomes-based curriculum has also been developed for school librarians. An ICT training initiative funded by a charitable lottery has resulted in the creation of a large number of training organizations, many of which are public-private partnerships. The largest of these is the partnership between the Open University School of Education and Research Machines Ltd.

A different approach has been taken in Scandinavia. A standard test was first developed that focused on ICT skills. It is known as the European Computer Driving License (ECDL) and is used in many professions and with students in schools. More recently, a Pedagogical ICT Driving License (the Paedagogisk IT-kørekort) has been developed for primary and secondary school teachers in

Denmark for the integration of ICTs in education. It is organized into modules that teachers study in small groups, preferably with teachers in the same school working on a coherent plan under the guidance of a distant tutor. Table 3.2 provides a list of the two modular curricula.

South America

Several countries in South America have extensive projects to develop and integrate ICTs in education, but the lack of national policies for the use of ICTs is notable. The *Enlaces* project in Chile, discussed later in this section, represents an exemplary national approach. SRI provided an international independent review of this initiative called *World Links for Development*. The project recommended the following for Brazil:

- Articulation and dissemination of a vision of how ICTs fit into the broader society and education. Together policy-makers and educators can build a strong national policy that clearly outlines how ICTs advance national goals and promote innovation use of ICTs to improve teaching and learning.
- Emphasize technology integration and interdisciplinary collaborative projects as the main topics for teacher training, and tie ICTs use to the development of basic skills in students. (SRI Brazil Report, 2001, p. 10)

These recommendations fit well with the Framework illustrated in Figure 2.1 and with projects in Europe (e.g. the UK and Denmark) that have curriculum approaches that build teamwork among teachers within and among schools.

International

The final example provided is the generic curriculum used by the international Intel Applying Computers in Education (ACE) project (Intel, 2002). The project trains classroom teachers to integrate the use of computers into existing curriculum to increase student learning and achievement. Originated in the USA in 1998, it is now in operation in several countries. The curriculum is summarized by these themes of training:

- Using computers and learning and productivity tools for both teachers and students.

Table 3.2. The Primary and Secondary School Modular Programmes Operating in Denmark, Managed by UNI.C.

Primary	Secondary
(All modules compulsory)	Compulsory modules (3)
Basic knowledge of computers and electronic communication	ICTs and education – organization, educational tools, electronic communication
Process-oriented work and text processing	Internet and education – web resources, production of own web pages, evaluation
Basic Internet use	Production of own education material – for screen and paper
The use of spreadsheets	Optional Modules (3–4)
Layout and pictures in communication	Talking to the eye – presentations
Information retrieval in databases and data processing	Digital pictures – visual effects
Screen presentation - multimedia and the web	Digitizing the world – collection and presentation of experimental data
School development	Production of own web sites
	Data collection and processing – spreadsheet and questionnaire Multimedia Project work and ICTs Languages and ICTs Textual work and text production Subject specific modules (1–2) 35 options available

- Using the types of computers and software that are widely available in both schools and industry.
- An emphasis on "hands-on" learning and the creation of lessons which teachers can effectively use in their classrooms.
- Encouraging teachers to work in teams, problem-solve and participate in peer-review of their lessons. (ACE project, 2002)

CURRICULUM DEVELOPMENT

A first step in determining the ICT curriculum for a university teacher education programme is to examine the expectations identified in the ICT standards for students, or standards for teachers aligned with the student standards. Through the

ongoing use of technology in the schooling process, students should achieve important technology capabilities. The key individual in helping students achieve those capabilities is the classroom teacher. The teacher is responsible for establishing the classroom environment and preparing the learning opportunities that facilitate students' use of technology to learn, communicate, and develop knowledge products; consequently, it is critical that all classroom teachers are prepared to provide their students with these opportunities. Teacher preparation programmes must provide technology-rich experiences throughout all aspects of the training programmes.

Teachers must be prepared to empower students with the advantages technology can bring. Schools and classrooms, both real and virtual, must have teachers who are equipped with technology resources and skills and who can effectively teach the necessary subject matter content while incorporating technology concepts and skills. Real-world connections, primary source materials, and sophisticated data-gathering and analysis tools are only a few of the resources that allow teachers to provide heretofore unimaginable opportunities for developing their students' conceptual understandings.

Traditional educational practices no longer provide pre-service teachers with the skills necessary to teach students to survive economically in today's workplace. Teachers must prepare their students to apply strategies for problem solving, and to use appropriate tools for learning, calculating, collaborating, and communicating. The following chart, Table 3.3, lists characteristics representing traditional approaches to learning and the corresponding strategies often associated with new learning environments for P-12 students. ICT tools and resources can contribute dramatically to establishing these new learning environments, both in P-12 schools and in colleges of education.

ICT competencies must be integrated into the curricular and pedagogical content presented, preparing teacher candidates to create the new learning environments described in Section I. Teacher educators must therefore model the use of these new learning environments in their own university classrooms.

The curriculum for teacher educators is often rich with strategies for presenting subject matter and pedagogy; however, it may be lean in terms of integrating technological tools for supporting that learning. Consequently, curriculum developers for teacher preparation programmes must be vigilant in identifying appropriate ways to apply ICT tools throughout the coursework and experiences planned for pre-service teachers.

Table 3.3. Establishing New Learning Environments

Incorporating New Learning Strategies	
<i>Traditional Learning Environments</i>	<i>New Learning Environments</i>
Teacher-centred instruction	Student-centred learning
Single-sense stimulation	Multisensory stimulation
Single-path progression	Multipath progression
Single media	Multimedia
Isolated work	Collaborative work
Information delivery	Information exchange
Passive learning	Active/exploratory/inquiry-based learning
Factual, knowledge-based learning	Critical thinking and informed decision-making
Reactive response	Proactive/planned action
Isolated, artificial context	Authentic, real-world context

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USING MODEL STRATEGIES FOR INTEGRATING ICTs INTO TEACHING

In an effort to implement ICT standards in a variety of coursework taken by pre-service teachers across all subject disciplines, a number of methods and strategies have been identified. Many of these strategies employ commonly used productivity tools such as word processing, database, spreadsheet, or browser applications. These software tools can be used in countless ways to support the subject area curricula.

Additional strategies, that are multipurpose in application, may also be used to help teacher candidates quickly develop technology-rich lessons for Their fieldwork. An overview of proven effective models and strategies for web-based lessons, multimedia presentations, telecomputing projects, and online discussions is presented below.

Web-Based Lessons

WebQuests

A WebQuest is an inquiry-oriented activity in which most or all of the information used by learners is drawn from the Web. WebQuests are designed to use learners' time well, to focus on using information rather than looking for it, and to support learners' thinking at the levels of analysis, synthesis, and evaluation. The WebQuest model (Table 3.4) has been effectively applied to all levels of education, from elementary to postgraduate study, and in many different subject Areas. The WebQuest provides teachers an option of reviewing and selecting web-based learning activities in a lesson-type format.

Table 3.4: The WebQuest Model

WebQuest Lesson Format
Introduction – orients the learner to what is coming and creates interest in the lesson
Task – describes what the learner should have completed at the end of the exercise
Process – describes the steps the learner should go through in completing the task
Resources – gives a list of Web pages the instructor has located that will help the learner accomplish the task
Evaluation – provides a rubric for examining six aspects of the student product
Conclusions – presents an opportunity to summarize and reflect upon the experience, examines the process, generalizes what was learned.

WebQuest, February 22, 2002.

The WebQuest model encourages teachers to create for their students new activities and adapt successful ones to take advantage of the Web's power. A higher-level application of this model has students develop their own Web-Quest activities to support the subject matter they are studying, and share the WebQuests with their peers. (San Diego State University, 2002)

CyberGuides

CyberGuides include standards-based, web-delivered units of instruction centred on core works of literature. CyberGuides provide a quick supplementary set of activities for students (and pre-service teachers) as they explore specific pieces of literature. Each CyberGuide contains a student and teacher edition, targeted standards, a description of the task, a process by which the task may be completed, teacher-selected web sites, and an assessment rubric. The teacher's guide includes an overview of the activities, suggestions from the author, and a library of links. The student guides include activity directions written in a format appropriate for the age and reading ability of the students. One example of a CyberGuide unit (for the intermediate grades) is "Dragonwings" by Laurence Yep (2001).

Multimedia Presentations

Multimedia combines media objects such as text, graphics, video, animation, and sound to represent and convey information. In this project-based method of teaching and learning, students acquire new knowledge and skills by designing, planning, and producing a multimedia product.

Many teachers find that students are motivated to learn when they can use technology to present the results of a rich project or activity. The multimedia presentation contains content conveyed by the student's selection of media. The teachers in training can look at examples of projects and lessons, at Internet sites housing collections of student samples. Some examples of multimedia presentations include:

- creating a web page or site;
- developing a branching hypermedia stack;
- using a multimedia slide show application to create a computer presentation;
- shooting and editing video to create a computer-generated movie.

As new forms of multimedia are explored, the types of projects become more complex. Multimedia-authoring tools are used to link and branch screens, making them interactive and layered with information in photos, scanned images, movies, and text. Students and candidates can easily narrate their projects using a microphone.

Telecomputing Projects

Telecomputing projects are Internet-enriched learning activities that often involve students in one location collaborating with students or adults in one or more other locations. They may share, among other things:

- experiences
- beliefs
- data
- information
- problem-solving strategies
- products they have developed or jointly developed.

Telecomputing tools include email, electronic mailing lists, electronic bulletin boards, discussion groups, web browsers, real-time chatting, and audio- and video-conferencing. Online resources include web sites, interactive environments, and remotely operated robotic devices. Judi Harris provides a variety of telecomputing project web pages. (Harris, 2001)

Online Discussions

A common type of telecomputing activity is online discussion. With the growth of infrastructure around the world comes the ability to access others through remote connections. Students and teacher candidates can connect to experts and peers through a variety of formats, such as chat rooms, electronic bulletin boards, and email. Communicating online offers participants freedom to send and receive information efficiently across diverse geographic locations. Communication can occur asynchronously allowing time for reflection, or to compensate for varying time zones. In real-time online communication, as in chat groups, the communication is synchronous and provides immediate feedback for reinforcement and understanding. Examples of online environments include email lists and virtual meeting places such as *Tapped In* (SCR International, 1995). Tools such as Blackboard (2002), and WebCT (2002) may be used to create online environments.

Particular care should be taken when planning these activities across cultures and languages. Online discussions can provide rich learning experiences as the inter-cultural exchanges develop both linguistic skills and cultural knowl-

edge. One successful strategy is for students to read in the target language, while writing in their native language.

The Three Pomegranate Network of Armenian provides an excellent example of connecting a society in Diaspora-almost two thirds of Armenians live outside their contemporary homeland (Kacherian, Margaryan, Gabrielyan, and Mamyan, 2000). The project links different Armenian schools across the world, each with varying degrees of access to technology and training, but all wishing to strengthen their awareness of a shared personal heritage, including the Armenian language and alphabet.

The ICT curriculum for Armenian teachers is project-based and structured around a task, such as the production of a web-based newsletter. The project provides valuable strategies for the planning of curriculum across cultures and schools, which are summarized as follows:

- *Language:* Instructions and other input from the project designers are bilingual. Students work in the target language, Armenian in this case. Software has been developed to include the target language alphabet.
- *Points of contact:* Schools serving Armenian children are linked electronically to schools in Armenia in the collaborative projects. Home and community centres need careful development to act as coordinating centres for curriculum projects.
- *Informal catalyst:* An informal catalyst to collaboration is necessary. In this project, the school in Armenia always takes this role.
- *Community building:* the projects, exercise and games are specially designed for the Diaspora, including activities that introduce students new to their culture.
- *Connectivity:* The project uses a flexible set of connectivity solutions including: direct access, connectivity centres, the Web, and CD's as a means of providing wider access.

They further give guidance in setting up such a network, emphasizing the important role of ICT teacher educators and leaders. These recommendations link closely with the principles for infusing ICTs into teacher education discussed in Section II. There is a significant need for highly committed project managers to shepherd the project through its various stages. These stages include web and learning-activity design, identifying participants from a world-wide audience, and overcoming many logistical issues associated with adding

content to a school curriculum and identifying Internet resources (Kacherian, Margaryan, Gabrielyan, and Mamyan, 2000).

Projects such as this will be exhibited and supported through the Universal Forum of Cultures Education project (Forum Universal de les Cultures, 2002). Applications to participate are available online. Guidance on the creation and support of virtual learning communities and information on potential partners may also be found in these and other web sites.

Approaches to Quality Assurance

Quality assurance in teacher education is an ongoing process and is demonstrated in a number of different ways. The teacher education institution itself may be scrutinized along with individual programmes within the institution. The quality of the teacher education institution and its programmes is often judged by the performance of the teachers they produce and the success of their graduates in effecting improved student learning in their P-12 classrooms. Quality assurance is often determined through an accreditation process. Demonstrated competence of teacher candidates in use of ICTs in teacher education has become increasingly important in making accreditation, certification, and programme review decisions. This is particularly true in the two countries that have adopted detailed national standards, the United States and the United Kingdom.

Quality assurance is uncommon in other countries, except through the evaluation of projects and strategic initiatives. Those forms of quality assurance are discussed in Section IV. The following is an illustration of a detailed form of curriculum quality assurance prevalent in pre-service teacher education in the USA.

NATIONAL ACCREDITATION STANDARDS FOR ICTs IN TEACHER PREPARATION IN THE USA

In the USA, the National Council for Accreditation of Teacher Education (NCATE) recognizes high quality university programmes through an accreditation process. NCATE provides national accreditation standards for the teacher education unit and for a variety of programmes within the unit, including those preparing candidates specializing in ICTs. NCATE has developed a strong collaboration with the professional association, International Society for Technology in Education (ISTE), and its standards, described earlier in this section. ISTE is responsible for recommending to NCATE the standards for pro-

programmes preparing Secondary Teachers of Computer Science, school-level Technology Facilitators, and Technology Directors for districts or regional areas. ISTE is also responsible for reviewing the NCATE Programme Reports from universities seeking national recognition for their ICT programmes.

The ISTE affiliation with NCATE has resulted in strong accreditation guidelines for technology in teacher preparation programmes, as well as programmes preparing individuals for leadership roles in planning and implementing ICTs in educational environments. Guidelines are also in place identifying the requirements for technology integration throughout teacher preparation programmes, as required by the new performance-based NCATE Standards adopted in May 2000. In their institutional report, each unit, or college of education, seeking initial accreditation is required to submit its conceptual framework outlining the philosophical and pedagogical underpinnings of the programme as a precondition for NCATE accreditation eligibility. The framework provides direction for programmes, courses, teaching, candidate performance, scholarship, service, and unit accountability. In addition to addressing the standards, the unit's document must include an overview of their institutional conceptual framework. One of six major indicators required when describing the conceptual framework is the unit's "Commitment to Technology" for the teacher preparation programme. The indicator states:

Commitment to Technology. The unit's conceptual framework(s) reflects the unit's commitment to preparing candidates who are able to use educational technology to help all students learn; it also provides a conceptual understanding of how knowledge, skills, and dispositions related to educational and information technology are integrated throughout the curriculum, instruction, field experiences, clinical practice, assessments, and evaluations. (NCATE, 2002, p. 13)

Other indicators include shared vision, coherence, professional commitments and dispositions, commitment to diversity, and candidate proficiencies aligned with professional and state standards. All universities seeking accreditation must verify their commitment to technology within their conceptual framework. Many universities reference the ISTE NETS for Teachers when preparing their descriptions of their technology commitment. In addition to clearly identifying the unit's commitment to technology in the conceptual framework, technology requirements are included within the NCATE unit standards themselves. The NCATE 2000 standards chart in Table 3.5 includes in italics the specific reference within the NCATE standards related to integration of technology.

In addition to the commitment to technology expressed in the conceptual framework for the university, the accreditation standards have also interwoven the ICT requirements throughout the assessment rubric.

RECOMMENDATIONS

Based on the above points the following recommendations may help agencies and organizations in UNESCO Member States to plan curricula:

- Use the *Framework for Information and Communication Technologies (ICTs) in Teacher Education* from Section II (Figure 2.1) when planning for infusion of ICTs.
- When planning curriculum, be sure it is congruent with the educational vision, the culture, and the context of each region, both locally and globally. Develop the vision and standards in stages, starting with a core that can be expanded into a set of standards, implemented with ICTs, for the preparation and continuing professional development of teachers.
- The ICT curriculum should facilitate change toward a more inclusive approach that promotes positive and supportive interdependence between students and teachers, while maintaining individual accountability and autonomy.
- Plan the curriculum to promote inter-cultural collaboration, and develop a learning community within and between schools and countries, using shared and complementary approaches with languages and cultures.

Table 3.5. NCATE 2000 Standards Chart

STANDARDS	ELEMENT	TARGET RUBRIC
I. CANDIDATE PERFORMANCE Standard 1. Candidate Knowledge, Skills, and Dispositions	Professional Knowledge and Skills for Other School Personnel	Candidates have an in-depth understanding of professional knowledge in their fields as delineated in professional, state, and institutional standards. They collect and analyze data related to their work, reflect on their practice, and <i>use research and technology to support and improve student learning.</i>
Standard 2. Assessment Systemme and Evaluation	Assessment Systemme	The unit, with the involvement of its professional community, is implementing an assessment system that reflects the conceptual framework(s) and incorporates candidate proficiencies outlined in professional and state standards. The unit continuously examines the validity and utility of the data produced through assessments and <i>makes modifications to keep abreast of changes in assessment technology and in professional standards.</i> Decisions about candidate performance are based on multiple assessments made at multiple points before programme completion. Data show the strong relationship of performance assessments to candidate success. The unit conducts thorough studies to establish fairness, accuracy, and consistency of its performance assessment procedures. It also makes changes in its practices consistent with the results of these studies.
	Data Collection, Analysis, and Evaluation	The unit is implementing its assessment system and providing regular and comprehensive data on programme quality, unit operations, and candidate performance at each stage of a programme, including the first years of practice. Data from candidates, graduates, faculty, and other members of the professional community are based on multiple assessments from both internal and external sources. Data are regularly and systematically compiled, summarized, analyzed, and reported publicly for the purpose of improving candidate performance, programme quality, and unit operations. <i>The unit is developing and testing different information technologies to improve its assessment system.</i>

STANDARDS	ELEMENT	TARGET RUBRIC
II. UNIT CAPACITY Standard 3. Field Experiences and Clinical Practice	Design, Implementation, and Evaluation of Field Experiences and Clinical Practice	Field experiences allow candidates to apply and reflect on their content, professional, and pedagogical knowledge, skills, and dispositions in a variety of settings with students and adults. Both field experiences and clinical practice extend the unit's conceptual framework(s) into practice through modelling by clinical faculty and well-designed opportunities to learn through doing. During clinical practice, candidate learning is integrated into the school programme and into teaching practice. Candidates observe and are observed by others. They interact with teachers, college/university supervisors, and other interns about their practice regularly and continually. They reflect on and can justify their own practice. Candidates are members of instructional teams in the school and are active participants in professional decisions. <i>They are involved in a variety of school-based activities directed at the improvement of teaching and learning, including the use of information technologies.</i> Candidates collect data on student learning, analyze them, reflect on their work, and develop strategies for improving learning. Clinical faculty are accomplished school professionals who are jointly selected by the unit and partnering schools. Clinical faculty are selected and prepared for their roles as mentors and supervisors and demonstrate the skills, knowledge, and dispositions of highly accomplished school professionals.
Standard 4. Faculty Qualifications, Performance, and Development	Modelling Best Professional Practices in Teaching	Faculty have an in-depth understanding of their fields and are teacher scholars who integrate what is known about their content fields, teaching, and learning into their own instructional practice. They exhibit intellectual vitality in their sensitivity to critical issues. Teaching by the professional education faculty reflects the unit's conceptual framework(s), <i>incorporates appropriate performance assessments, and integrates diversity and technology throughout coursework, field experiences, and clinical practices.</i> Faculty value candidates' learning and adjust instruction appropriately to enhance candidate learning. They understand assessment technology, use multiple forms of assessments in determining their effectiveness, and use the data to improve their practice. Many of the unit faculty are recognized as outstanding teachers by candidates and peers across campus and in schools.

STANDARDS	ELEMENT	TARGET RUBRIC
Standard 6. Unit Governance and Resources	Unit Personnel	Workload policies and practices permit and encourage faculty not only to be engaged in a wide range of professional activities, including teaching, scholarship, assessment, advisement, work in schools, and service, but also to professionally contribute on a community, state, regional or national basis. <i>Formal policies and procedures have been established to include on-line course delivery in determining faculty load.</i> The unit's use of part-time faculty and of graduate teaching assistants is purposeful and employed to strengthen programmes, including the preparation of teaching assistants. Clinical faculty are included in the unit as valued colleagues in preparing educators. Unit provision of support personnel significantly enhances the effectiveness of faculty in their teaching and mentoring of candidates. The unit supports professional development activities that engage faculty in dialogue and skill development related to emerging theories and practices.
	Unit Facilities	The unit has outstanding facilities on campus and with partner schools to support candidates in meeting standards. <i>Facilities support the most recent developments in technology that allow faculty to model the use of technology and candidates to practice its use for instructional purposes.</i>
	Unit Resources including Technology	The unit aggressively and successfully secures resources to support high-quality and exemplary programmes and projects to ensure that candidates meet standards. The development of and implementation of the unit's assessment system is well funded. <i>The unit serves as an information technology resource in education beyond the education programmes to the institution, community, and other institutions. Faculty and candidates have access to exemplary library, curricular, and/or electronic information resources that serve not only the unit but also a broader constituency.</i>

NCATE, 2002.

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IV.

ESSENTIAL COMPONENTS TO SUPPORT ICTs IN TEACHER DEVELOPMENT

When a university, teacher education unit, state, region or country adopts or adapts a set of standards for determining how technology will be infused throughout their programmes, it is critical that faculty in the teacher education programmes be included in the planning effort. The faculty will plan for ICTs in teacher development considering their own conditions, culture, and context. During this collaborative planning phase, the teacher education unit and other university units providing courses for pre-service teachers (i.e. teacher candidates) should develop plans that not only address the four key components within the framework, but also the elements that support long-term implementation of the key components—leadership and vision, context and culture, planning and management of change, and lifelong learning. These elements are necessary for a supportive environment and a successful, self-sustaining implementation of technology infusion within the teacher education programme.

Experience has shown that a number of essential conditions must be met to successfully integrate ICTs into teacher education programmes. As educational entities have implemented ICTs in teacher education, researchers and evaluators have identified barriers that prevent or restrict successful technology infusion. Teacher educators express frustration by stating, "I am having problems implementing our plan for infusion of ICTs because..." Such statements are often completed by one or more conditions quite common among teacher education institutions around the world. ISTE has compiled a list of the most commonly cited conditions necessary to create learning environments conducive to powerful uses of technology. Table 4.1, Essential Conditions for Implementing NETS for Teachers, lists these crucial elements for addressing ICT needs in teacher education.

When planning for implementation of ICTs in teacher education, the planning team should consider each essential condition and note whether, and to what extent, it is present. The context, culture, and extent of collaboration among stakeholders will affect how adequately the conditions are met and determine what types of strategies might solicit support if the essential conditions are not currently present. Each of these conditions is examined in this section.

Shared Vision

Defined as the presence of proactive leadership and administrative support, shared vision means that the commitment to technology is systemic. From the administration to the grounds personnel, there is an understanding of, commitment to, and sense of advocacy for the implementation of technology. When the implementation of a technology initiative is problematic, a major reason often cited is a breakdown in the common understanding of the institution's goals among those who hold the decision-making power. These situations can occur over something as simple as unlocking the door to a lab, or as complex as modifying existing operational budgets to provide allocations for technology funding. Facilitating the integration of technology may require a change in policy or rules, and the decision-makers have to be willing to look at the situation, forge compromises when necessary, and ensure communication among all parties. The collaborative environment necessary for creating a shared vision is also needed to sustain that vision.

Access

The fact that educators need access to current technologies, software, and telecommunications networks seems simple. However, this access must be consistent across all the environments that are part of the preparation of teachers. Most teacher education programmes involve several entities, including at least a college or university and one or more schools in the P-12 range. The access to funding and other resources may vary greatly among these partners, yet ideally, access should be adequate and consistent throughout the educational experience of students in the process of becoming teachers. Creative partnerships are often required to make this happen.

Additionally, there needs to be access to technology appropriate to the subject areas being studied, such as word processing programs and Internet access in English, or computer labs and microscopes for science labs. Access must be in

Table 4.1. Essential Conditions for Implementing ICTs in Teacher Education

Shared Vision	There is proactive leadership and administrative support from the entire system.
Access	Educators have access to current technologies, software, and telecommunications networks.
Skilled Educators	Educators are skilled in the use of technology for learning.
Professional Development	Educators have consistent access to professional development in support of technology use in teaching and learning.
Technical Assistance	Educators have technical assistance for maintaining and using the technology.
Content Standards and Curriculum Resources	Educators are knowledgeable in their subject matter and current in the content standards and teaching methodologies in their discipline.
Student-Centred Teaching	Teaching in all settings encompasses student-centred approaches to learning.
Assessment	There is continuous assessment of the effectiveness of technology for learning.
Community Support	The community and school partners provide expertise, support, and resources.
Support Policies	School and university policies, financing, and rewards structures are in place to support technology in learning. (ISTE, 2000)

classrooms as well as lab settings, and provisions must be made for special populations. The technology should be accessible immediately when it is the best route to the information or tools needed by pre-service teachers, teachers, and students. Furthermore, university model classrooms are important for determining the way technology should be used in the P-12 environment. There should be an instructor station with a presentation system and 4-6 stations for pre-service teachers. The teacher candidates need to see and experience models that demonstrate the kind of access desired in the classroom.

In addition to ICT access in their coursework, pre-service teachers must have technology access in their student teaching environments and in their classrooms in the induction year and beyond. Otherwise, opportunities to use technology tools for teaching students or communication tools for mentoring or staying connected with parents will be limited.

Skilled Educators

The educators who work with teacher candidates must be skilled in the use of technology for learning. They must be able to apply technology in the presentation and administration of their coursework and facilitate the appropriate use of technology by their teacher candidates. From the first course taken by a freshman, through collaborative work at the school site, pre-service teachers should participate with and observe their mentors using technology effectively. The teacher educator should model and teach techniques for managing technology in the classroom and for communicating outside the classroom through electronic means.

Professional Development

Even in contexts in which professional development is extensive, it is important to provide consistent access to professional development as the technology constantly changes. Ongoing opportunities for professional development should be available to university and P-12 faculty and administrators who participate in the preparation of teachers. The venues and delivery mechanisms should take into consideration issues of time, location, distance, credit options, and so on. Professional development is not a one-time event it should be focused on the needs of the faculty member, teacher, or administrator and sustained through coaching and periodic updates.

Technical Assistance

Educators need technical assistance to use and maintain technology. The focus of the faculty member, teacher, and pre-service teacher should be on teaching and learning, not on maintaining and repairing the technology beyond basic troubleshooting procedures. When the technology does not function well, a learning opportunity is lost and faculty frustration grows. Timely technical assistance is imperative for faculty and candidates to feel confident that they can use technology in their teaching and learning. There are many ways technical assistance can be obtained, including asking community members or student assistants to maintain a help desk. It is a critical factor for success in implementing ICTs.

Content Standards and Curriculum Resources

Educators must be knowledgeable in the content, standards, and teaching methodologies of their disciplines. Teacher candidates must learn to use tech-

nology in powerful, meaningful ways in the context of teaching content. Technology brings relevant resources from the real world to subject area content, provides tools for analyzing and synthesizing data, and conveys content through a variety of media and formats. Pre-service teachers should learn to use technology in ways that meet the content standards and the technology standards for students and teachers.

Student-Centred Teaching

Teaching in all settings should encompass student-centred approaches to learning. Technology should not be used only as a tool for demonstration, as an electronic overhead projector or blackboard; rather the use of technology by students should be an integral part of instruction. In student-centred approaches to learning, students become the source for problems investigated. Students and teacher candidates must have opportunities to identify problems, collect and analyze data, draw conclusions, and convey results using electronic tools to accomplish these tasks. Faculty should model the use of ICTs to demonstrate their usefulness and appropriateness for collaboration, acquisition of resources, analysis and synthesis, presentation, and publication.

Assessment

In addition to assessing teaching and student outcomes, institutions should continuously assess the effectiveness of technology for learning throughout the entire teacher preparation environment. The data obtained from this continuous assessment will:

- inform the learning strategies used,
- ensure that the vision for technology-use maintains the appropriate direction,
- pinpoint potential problems, and
- provide data for altering policies and instructional strategies or for acquiring resources.

Changes made over time due to technology innovation will exemplify informed decision-making.

Table 4.2. ISTE NETS Essential Conditions for Technology in Teacher Education

The following chart provides guidelines for the essential conditions that should be in place for each phase in the teacher preparation process in order to support effective use of technology to improve learning, communications, and productivity.

General Preparation	Professional Preparation	Student Teaching/ Internship	First-Year Teaching
Shared Vision – There is proactive leadership and administrative support from the entire system.			
University leaders share a vision for technology use in all appropriate courses and content areas.	The professional education administration and faculty share a vision for technology use to support new modes of teaching and learning.	University personnel, teachers, and school administrators at the cooperating school site share a vision for technology use in the classroom.	Schools, districts, and universities share a vision for supporting new teachers in their use of technology in the classroom.
Access – Educators have access to current technologies, software, and telecommunications networks.			
Access to current technologies, software, and telecommunications networks is provided for all students and faculty both inside and outside the classroom.	Access to current technologies, software, and telecommunications networks is provided for teacher education faculty, classes, and field sites, including technology-enhanced classrooms that model environments for facilitating a variety of collaborative learning strategies.	Access to current technologies, software, and telecommunications networks is provided for student teachers/interns and their master teachers/ mentors/ supervisors in the classroom and professional work areas.	Access to current technologies, software, and telecommunications networks is provided for new teachers for classroom and professional use, including access beyond the school day.
Skilled Educators – Educators are skilled in the use of technology for learning.			
Faculty teaching general education and major courses are knowledgeable about and model appropriate use of technology in their disciplines.	Teacher education faculty are skilled in using technology systems and software appropriate to their subject area specialty and model effective use as part of the coursework.	Master (cooperating/supervising) teachers and university supervisors model technology use that facilitates students' meeting the ISTE National Educational Technology Standards for Students.	Peers and administrators are skilled users of technology for teaching and school management.

General Preparation	Professional Preparation	Student Teaching/ Internship	First-Year Teaching
Professional Development – Educators have consistent access to professional development in support of technology use in teaching and learning.			
University faculty and students are provided with opportunities for technology skill development and reward structures that recognize the application of technology in teaching, learning, and faculty collaboration.	Personnel in teacher education and field experience sites are provided with ongoing professional development.	Cooperating/master teachers and supervisors of student teachers/interns are readily provided with professional development in applications of technology in teaching.	Faculty has continuous access to a variety of professional development opportunities in several delivery modes, with time to take advantage of the offerings.
Technical Assistance – Educators have technical assistance for maintaining and using the technology.			
Timely technical assistance is available for all faculty to ensure consistent, reliable functioning of technology resources	Technical assistance for teacher education faculty and students is readily accessible and includes expertise in the use of technology resources for teaching and learning in PK-12 settings.	In field-experience settings, technical assistance is on-site to ensure reliability of technology resources.	Technical assistance for faculty and staff is timely, on-site, and includes mentoring to enhance skills in managing classroom software and hardware resources.
Content Standards and Curriculum Resources – Educators are knowledgeable in their subject matter and current in the content standards and teaching methodologies in their discipline.			
Prospective teachers have knowledge in the subject area(s) they intend to teach.	Technology-based curriculum resources that address subject matter content standards and support teaching, learning, and productivity are available to teacher candidates.	Technology-based curriculum resources that are appropriate in meeting the content standards in teaching areas and grade ranges are available to teacher candidates at the student/intern site.	The school district provides professional development opportunities related to local policies and content standards and the technology-based resources to support the new teacher's efforts to address those standards.

General Preparation	Professional Preparation	Student Teaching/ Internship	First-Year Teaching
Student-Centred Teaching – Teaching in all settings encompasses student-centred approaches to learning.			
University faculty incorporate student-centred approaches to learning (e.g., active, cooperative, and project-based learning).	Teacher education faculty and professional teaching staff model student-centred approaches to instruction in education coursework and field experiences.	Opportunities to implement a variety of technology-enhanced, student-centred learning activities are provided for teacher candidates/ interns.	Faculty routinely use student-centred approaches to learning to facilitate student use of technology.
Assessment – There is continuous assessment of the effectiveness of technology for learning.			
University faculty and support staff assess the effectiveness of technology for learning to examine educational outcomes and inform procurement, policy, and curriculum decisions.	Teacher education faculty and professional teaching staff model the integration of teaching and assessment to measure the effectiveness of technology-supported teaching strategies.	Cooperating/master teachers work with student teachers/ interns to assess the effectiveness of student learning and of technology in supporting that learning.	The district and school site support the classroom teacher in the assessment of learning outcomes for technology-supported activities to inform planning, teaching, and further assessment.
Community Support – The community and school partners provide expertise, support, and resources.			
Prospective teachers experience technology use in real-world settings related to their general education and courses in their majors.	Teacher preparation programmes provide teacher candidates with opportunities to participate in field experiences at partner schools where technology integration is modelled.	Student teachers/interns teach in partner schools where technology integration is modelled and supported.	Schools provide beginning teachers with connections to the community and models of effective use of local and other resources.

General Preparation	Professional Preparation	Student Teaching/ Internship	First-Year Teaching
Support Policies – School and university policies, financing, and rewards structures are in place to support technology in learning.			
University faculty are provided with resources for meeting subject area needs and with reward structures that recognize the application of technology in teaching, learning, and faculty collaboration.	Policies associated with accreditation, standards, budget allocations, and personnel decisions in teacher education programmes and field experience sites support technology integration. Retention, tenure, promotion, and merit policies reward innovative uses of technology by faculty with their students.	Student teaching/internships are located at sites where administrative policies support and reward the use of technology.	School induction-year policies, budget allocations, and mentoring assignments support the first-year teacher's use of technology. Hiring practices include policies regarding technology skills of prospective employees.

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Community Support

The visioning process includes the community and school partners who provide expertise, support, and resources for technology implementation. The community must see that technology is a valuable tool for prospective teachers and their students, and must be willing to support it in the political process from the boardroom to the state house.

Support Policies

Policies can either support or hinder the implementation of technology. As decision-makers develop new policies, they must consider how the policies affect acquisition of and access to technology. Some major barriers to the use of technology relate to faculty expectations about incentives and reward structures. The expectation for the use of technology must cut across all subject areas and

teacher preparation contexts so that faculty and teacher candidates are assured that their work will be valued.

Policies related to technical assistance should also support the use of technology rather than obstruct it. For example, although firewalls are essential in the university environment, there are ways to provide dial-up and remote access while maintaining the security of campus servers. Likewise, at the school level, there are ways to control students' Internet access to unwanted images and information while maintaining an environment of exploration and inquiry. To develop environments equipped to support the infusion of ICTs in teacher education, essential conditions identified on Table 4.2 must be present in each phase of an aspiring teacher's education in the university's general education programmes, in the chosen subject specialization, in teacher education coursework, and at the school sites hosting student teachers and interns. Teachers and teacher educators cannot be expected to implement what they have learned about effective use of ICTs without the presence of essential conditions in their work environment. The following environments correspond to stages of development commonly experienced during university preparation:

- General Preparation-general university courses providing instruction in the foundational courses for all students and the specific coursework in the student's major field of study
- Professional Preparation-formal coursework in professional education
- Student Teaching/Internship-supervised, extended field experience in the P-12 classroom
- First-Year Teaching-the initial year of P-12 classroom teaching

Recognition of the essential conditions necessary in all the environments that contribute to the preparation of teachers underscores the shared responsibility for preparing new teachers. The university, teacher education unit, and P-12 education must advocate resources that fulfil the essential conditions for each crucial stage of teacher development.

Table 4.2 addresses planning issues related to each of the essential conditions for each of the four environments that support the ICT preparation of teachers.

Benchmarks and Self-Assessment Tools for ICTs in Teacher Education

In planning the integration of ICTs into teacher education, it is important for teacher education institutions to understand the knowledge and skills necessary for teachers to effectively use ICTs in their instruction. They must also understand the institution's level of readiness to integrate technology into the teacher education curriculum. To accomplish these goals requires that the teacher education institution understand the benchmarks, standards, and guidelines for ICTs in teacher education. It is also important that they have access to tools that help them assess their level of readiness and progress in infusing ICTs into the teacher education programmes. Section VI provides a list of resources that may be helpful in assessing the extent to which the essential conditions are currently met and to monitor future progress in meeting those conditions.

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V.

ICT PROFESSIONAL DEVELOPMENT

FOR TEACHER EDUCATORS, ORGANIZATIONS, REGIONS AND COUNTRIES

The challenge confronting countries, regions and universities is to address the following basic principles for ICTs in teacher education (Society for Information Technology and Teacher Education, 2002):

- ICTs should be infused into the entire teacher education programme.
- Technology should be introduced in context.
- Students should experience innovative ICT-supported learning environments in their teacher education programme.

The most critical factor in the successful integration of ICTs into teacher education is the extent to which the teacher educators have the knowledge and skills for modelling the use of ICTs in their own teaching practices. To enable them to develop these skills requires a well-conceived and sustained programme of professional development. This section focuses on the professional development of teacher educators and the programmes for which they are responsible, such as pre-service programmes and certificates for practising teachers. The section discusses teacher educator professional development in various contexts of infusing technology into the educational system and process. The discussion is underpinned by new approaches to teaching and learning and by the recognition of the stages of professional and organizational development. Eight case studies from around the world illustrate a range of approaches and models that may be used. The section closes with a brief discussion of the importance of robust evaluations and the role of all stakeholders in the evaluation process.

BASIC STRATEGIES

Countries that have initiated efforts to infuse ICTs into teacher education have found four professional development strategies helpful in successful technology integration. First, professional development needs to focus on teaching and learning rather than on hardware and software. It should be designed by first considering what student teachers are expected to know and be able to do in a specific discipline, and then infusing ICTs into the learning process so that acquiring the knowledge and skills is more efficient.

Second, professional development is practically useless unless leaders and teacher educators are provided with access to technology resources and have the time and support-when needed – to apply the new knowledge and skills that they have learned. A just-in-time approach to professional development is a model that works well. In this approach, professional development is provided to teacher educators when they have a need or opportunity to use a specific technology tool or application to enhance learning. Third, professional development in the use of ICTs is not a one-time activity. To keep current with new developments means that professional development in ICTs must be an ongoing process.

A further strategy for professional development is to start in a small way. Start by providing professional development in the use of ICTs to a small group of teaching staff. Perhaps this group will have volunteered or demonstrated that they have basic ICT competencies for personal use, or have expressed personal interest in using ICTs in their teaching. Working with this small group allows the professional development staff to determine the specific interests and needs of the teacher educators and what works best in the professional development process. Based on this experience, professional development may be provided to other small groups of faculty, thus expanding and refining the professional development efforts. Figure 5.1 shows a group of student teachers working on group project in such a model.

The most important criterion for effective professional development is to tailor it to the learning needs and skill levels of individual teaching staff within a faculty. This suggests that, ideally, an institution should, based on availability of resources, provide a variety of options for professional development for the faculty. In structuring professional development options and resources, it is helpful to explore collaboration opportunities with partners outside the university.

The opportunities for ICTs to create new paradigms of teaching and learning will depend largely on leadership and a shared vision, and on appropriate and continuing professional development.

Figure 5.1. Student Teachers Working Cooperatively on an IT Project



The planning and implementation of ICT-related professional development of teacher educators should be led by a planning group that includes representation and expertise from teacher educators, programme administrators, teachers, school administrators, technology experts, and business leaders. The diverse perspectives of the group should provide an understanding of the realities of the classroom, new views of the teaching-learning process, knowledge of the array of technologies that may be used to enhance learning, and community opinions. It is important for a planning group to negotiate a shared understanding of the role of ICTs in the agenda for educational renewal based on their individual cares and concerns (as described in Section VII on managing change through use of the CREATER model). It is also helpful to have a larger advisory or liaison group that may facilitate collaborative professional development efforts and sharing of resources across related organizations, for example, between the university and the partner schools where students are placed for teaching practice.

NEW APPROACHES TO TEACHING, LEARNING, AND ASSESSMENT

An important aspect of professional development is not only enabling teacher educators to understand and use ICT tools in their teaching practices, but understanding how technology coupled with new approaches to teaching and learning, may enhance student learning. Many teacher educators recognize that approaches to education are changing and that new technology has the potential to improve education and student learning. They may also recognize the implications of increasing use of technology in society and employment, including employment directly related to their own disciplines and content areas. Less obvious are the implications for literacy and numeracy at the core of the educational process, and the need for teacher educators themselves to model good practice in their teaching so that their students can easily transfer these strategies into their own teaching practice. Teacher educators are experts in a domain, and it is important to respect this domain while helping them to revitalize and modernize their teaching with ICTs. The principles that this document espouses for the curriculum and professional development of teachers become even more relevant when applied to teacher educators. Similarly, the risk that established teacher educators must take to develop their practice needs to be recognized and mitigated as much as possible.

The most significant change required of individuals and organizations providing teacher education is to redefine student roles and responsibilities (as discussed in Section I). This is referred to as student-centred learning, and in the context of teacher education means that control of the teaching-learning process must move away from the teacher educator to the student of teaching. Both students and teachers have always had rights and responsibilities, but the redefinition of the learning environment requires a change in the balance of rights and responsibilities, with the student assuming more of both. ICTs demand this shift because technologies are constantly changing. Students need to develop the ability to think for themselves, continually learn as technologies change, and provide support to one another. This last element, peer teaching, is a natural product of ICTs because often the younger generations bring increasingly high levels of competence into the learning environment. This is a positive shift, and it should be noted that these strategies (learning from peer support and reciprocal mentoring between teacher and learner) are also appropriate for competencies that do not involve ICTs.

STAGES OF PROFESSIONAL DEVELOPMENT FOR ICTs

Teachers and teacher educators develop ICT competence in stages. Those who are fluent with technology may not appreciate how difficult it is for technology novices to appropriate ICTs into their professional practice. Teacher educators often find this task even more difficult than teachers do, because they typically have higher levels of content and pedagogical expertise that must be respected. Teacher educators, because they have to work in multiple contexts-both the home institution and the field where students are placed to observe and practice teaching-may also be more influenced by the absence of the essential conditions for ICTs in teacher education (described in Section IV).

Four stages are common, but they may be repeated with new forms of ICTs or applications of ICTs to new areas. The first stage for each individual is awareness, and the appropriate response at this stage is to provide information about a relevant application of ICTs and appropriate ways that it may be used in the individual's current professional or personal concerns. Please note the learner-centred nature of this approach; the concerns are not those of the supporter (the ICT expert) or the organization, but of the individual teacher educator. Teacher educators then explore the use of the application. They need support to put this ICT application into practice in a timely manner and to reflect on its effectiveness. Only after teacher educators have gone through these stages are they able to adapt their practice to make better use of ICTs, and then move toward the final stage to become innovators and modellers of excellent practice for their students and colleagues. (These stages are described in the *Concerns-Based Adoption Model, CBAM*, and confirmed in ICT specific research, such as the *Apple Classroom of Tomorrow* described in Section VII, Managing Change.)

The advent of ICTs provides the opportunity to engage in this process from a new perspective and to model processes of learning for colleagues and students. It is acceptable for teacher educators to adopt only those aspects of ICTs that are relevant to their practice, but they must first be allowed to explore the range of possibilities, so that they and their students may become critically aware of, and competent in, diverse ICT applications. Of course, any teacher educators continually strive to be responsive to developments and innovations in education within and beyond their discipline.

CASE STUDIES

To understand the strategies of professional development it is important to understand how they are embedded in the broader context of the planning and implementation of ICTs in teacher education. The following section provides eight case studies. These illustrate an eclectic range of strategies. The first four case studies focus on strategies for individual teacher educators and their organizations. The second four include strategies for building capacity for ICT teacher education across regions and nations.

Each case study is analyzed by use of the framework for ICTs in teacher education illustrated in Figure 2.1. This holistic framework is used to understand the complex interaction of the professional development process. Teacher educators need to develop competence in the core themes of: pedagogy, collaboration and networking, technical competence, and social issues. This needs to be done within the local and global cultural contexts of: lifelong learning, leadership and vision, and planning and management of change.

Strategically Supported Workshops

A growing number of pre-service teacher education programmes in the USA have employed the ISTE technology standards, and ISTE describes the best of these programmes on the ISTE web site. One such programme was initiated at the University of Texas at Austin, where the teacher educators expert in ICTs have actively planned and promoted the professional development of their colleagues and facilitated the management of change. The culture is one in which all participants respect the leadership and vision provided by the dean and the college's technology support centre. The current programme evolved from the experiences gained in working with the teacher education faculty. It underscores the importance of learning from the mistakes, as well as the successes, in implementing professional development. For example, a faculty development workshop was held to teach faculty to use a tool to incorporate web-based elements into their teaching. An initial training session was offered that provided the faculty with an extensive demonstration of the full range of capabilities of the tool. The faculty participants left the two-hour session with cognitive overload and little that they could immediately apply to their courses.

Based on this experience, another workshop was designed that focused on a few useful applications that faculty could incorporate into their instruction. The teacher educators were asked to bring class syllabi and selected course resources

to the workshop. The teacher educators learned how to post these materials online in WebCT and set up online class discussions. After the teacher educators had time to see how this worked in practice with their students, a second workshop was provided to help them consider appropriate ways to facilitate collaboration and networking, along with the social issues that might arise in using these methods. These redesigned workshops were highly successful and led to ongoing faculty development.

This effort was successful because this strategy permitted the teacher educators to gain new information about the software within a pedagogical approach that addressed their immediate concerns, and allowed them to pilot the approach and evaluate their efforts. A similar strategy works for other widely used software application tools, such as word processing and desktop publishing.

Reciprocal Mentoring

Professional development for ICTs in teacher education is ongoing, as denoted by the theme of lifelong learning in Figure 2.1. Successful models for professional development must reflect this dynamic nature by building capacity rather than teaching skills. Reciprocal mentoring is an example of a professional development model that builds capacity within an organization.

Iowa State University has an award-winning programme of teacher education and supports this excellence by providing professional development in ICTs for its teacher educators and the in-service teachers who work with students. Over a decade ago, the course Technology and Teacher Education was established to provide graduate students with an internship experience. Many of these students become teacher educators who are expert in ICTs. These students mentored teacher educators in ICT skills and, in return, the teacher educators mentored the students in their profession. The graduate students' advisor, who strategically selected or negotiated the participation of teacher educators, facilitated and planned the interaction. Over the years, the balance moved from encouragement of reluctant teacher educators to participate, to the strategic choice of participants from a long list of volunteers. Similarly, the context and culture became increasingly akin to a sociable family that supports one another; an organization in which members learn from one another while collaborating and networking.

The mentoring course takes place in the fall semester. During weekly meetings, the graduate students learn about mentoring and a variety of approaches to infusing

technology into education. These meetings foster collaboration and networking among the graduate students, lend moral support, provide opportunities for the development of technical skills, and engage students with relevant literature. Each student also meets with his or her teacher educator mentee weekly and responds to their needs at an appropriate pace.

In the early stages of this process, many teacher educators develop confidence with ICTs very slowly, often starting with word processing of scholarly work or with the creation of slides using software. Technical competence is purposefully developed slowly, to keep pace with the emerging confidence and autonomy levels of the teacher educator. The graduate students' advisor insists that mentoring graduate students assist the teacher educator to engage with ICTs, rather than allow the teacher educator to delegate the ICT tasks to the student mentor. ICT applications used in instruction are favoured over those for research, so that the mentoring graduate student can support and experience the development of pedagogic competence. The mentor pairs are expected to engage in many rich conversations as they work together, covering diverse themes and competencies, including social issues with ICTs and discipline specific topics.

Toward the end of the semester, the teacher educators join the mentors' class for a celebration of their collaborative professional and course development. At this time the teacher educators are exposed to a wide range of ICT applications, cultures, and contexts, and reflect on the four themes and competencies. The graduate students' advisor also reflects on the programme's success in reaching department and university goals and gains new ideas for future planning. This model has been extremely successful, as measured by increased faculty competence in the use of technology and by the attitudes of graduate students and faculty. It has been adapted to various settings, including those in which undergraduate students are the mentors.

International Technology Transfer

Occasionally opportunities for collaborative projects are stimulated by requests for technology transfer proposals. This case study is of one such opportunity provided by the European Commission, which offered funding for faculty development to countries in Central and Eastern Europe (European Commission Telematics Programme, 2002). This case study illustrates the importance of considering all the elements presented in Figure 2.1 in designing and realizing ICT projects.

The MATEN (Multimedia Applications for Telematic Educational Networks) project provided technical and pedagogical support to countries in Central and Eastern Europe. It researched ways in which information and communication technologies affect instructional design in this region and the ways existing patterns of social interaction in education are shaping the evolution of software engineering (Multimedia Applications for Telematic Educational Networks, 2002).

The project provided funding for infrastructure to universities in Ukraine, Lithuania, and Russia, and provided support to encourage retention of faculty and teachers in countries in transition. Because of the project, they were able "to expand the Flexible Distance Learning Systems (FDLS) model to describe possible applications of different multimedia in curriculum and courseware design" (Multimedia Applications for Telematic Educational Networks, 2002). Two courses particularly relevant to this discussion are a course in ICTs for teachers in the former Soviet Union led by the Ukrainian Institute of Cybernetics in Kiev and a course at Kaunis University of Technology in Lithuania. The first stage of the course development took two years, followed by an additional contract to update and improve the courses with multimedia. This process set up the infrastructure and provided tailored ICT teacher education to the teacher educators who developed the first courses.

Rather than address the participants' stage of development, the project first took a more direct approach, with an assumption that content and technology could be simply linguistically translated for delivery. The participants, at an early stage in the professional development sequence, experienced more stress than success during these early days of the project. This demonstrated the need to carefully consider all elements of the framework in Figure 2.1 when inviting and judging proposals for ICT transfer into new educational contexts, in addition to considering the support for hardware, software, and related infrastructure.

The teacher educator participants had little experience of ICTs and were largely uninformed about recent pedagogical approaches, so their teaching tended to rely on textbooks and highly structured exercises. For this reason, a technology transfer course was created to enable the teacher educators to create a course suited to their own context and culture. A team developed the courses, and included teacher educators and ICT faculty from universities in these three countries as well as project staff.

This strategy permitted international experts to model appropriate pedagogic approaches, including collaboration and networking. The technology

transfer course was built upon an English university's online ICT masters programme provided over the Internet for in-service teachers. This online learning environment was adapted over time in response to the needs of the target teacher educators. The teacher educators were helped to develop their own pedagogical skills, as they created content that placed ICTs into the context and culture of their region's schools and universities. The teachers who completed high quality work received a certificate from the English university. This certificate motivated them and provided one form of quality assurance.

Although distance learning formed the core of this project, the on-site ICT faculty provided their teacher educator colleagues with training to develop technical competence, and handled the technical issues as they arose. This support was essential to the teacher educators as they moved through the stages of development. The local ICT faculty also created course materials for technical aspects, which were used by the teacher educators for their courses.

This project also illustrates the need to consider social issues when designing ICT professional development. There was difficulty in obtaining good access to ICTs for teacher educators due to their low status. This contributed to the stress they experienced as ICT novices and probably contributed to participant dropout. These and other social issues were sensitively handled by the project team as they arose. Other points identified in the framework under Social Issues did arise, including repeated attention to respect for copyright and intellectual property rights.

MATEN was a complex and ambitious project. Project staff provided vision and leadership and support for planning and the management of change. Dissemination activities carried out by the Ukrainian teacher educators spread the activities across the former Soviet Union and large numbers of teachers benefited from the course. These successes, although significant, could have been improved by making the process more transparent to those new to ICTs.

MirandaNet: A Community of Practice

Regional and international collaboration can provide ongoing mentoring and support for those who lead ICTs in teacher education for colleagues in their own schools and in other locations. One exemplary community is MirandaNet, which developed its first community in England to support teacher educators and teachers who lead ICT development (MirandaNet, 2002). This non-profit organization is more similar to a professional association than to a training agency or institution. It has collaborated with and received support from technology companies

in the development of ICTs in teacher education. MirandaNet builds communities of educator volunteers to develop educational use of ICTs in their own practice and that of colleagues. They do this through the sharing of information and resources, and discussions on the Internet. Social events provide face-to-face meetings that are also extremely important in developing the community spirit.

Communities in the Czech Republic and Chile have been created with support from the community in the UK, and the creation of a new community in China is currently being explored. Partnerships between MirandaNet and commercial ICT companies support the development of these communities. For example, Compaq supports selected teachers with personal portable computers and Oracle provides a free and safe Internet site for children and their teachers in the UK and the USA, with both English and Spanish interfaces.

All of the teachers and teacher educators who take part in the MirandaNet community demonstrate a commitment to lifelong learning, and they discuss the four themes and four competencies in the framework presented in Figure 2.1. As an example of the communication that occurs among project participants, the email list for MirandaNet in the UK is currently discussing 'Interactive whiteboards'. The question came from a member of the community (a teacher coordinating ICTs in a high school) who wanted recommendations on the hardware (technical issues), its placement (social issues) and the pedagogic applications for schools and ICT teacher education. The responses sent via the email list provide answers from a range of viewpoints, and the discussion also touches upon issues of safety and the management of change. The community also provided web sites for further information and invited colleagues to their organization to see a whiteboard's use. This collaborative network of teachers is modelling lifelong learning within a community of learners.

The members in the Czech Republic and Chile did not join in this particular discussion, because this item is rarely within their resources. They engage in discussions on topics more relevant to their needs and practices, such as ways to adjust foreign computers and software to local contexts. Such collaborative problem solving is important to many ICT teacher educators who have relatively little access to technical support or opportunities to view new developments. Visits between countries have strengthened community members. The exchange of information is two-way, as it flows from the wealthy to the less well-resourced and back again. All educational systems need more ICTs, and the resourcefulness of colleagues in challenging situations inspires all to better education. In addition, the inter-cultural education that takes place dramatically increases the quality of collaboration and networking.

Planning Professional Development for Regions and Countries

A number of states and regions have engaged in a renewal of education. Part of their strategy includes ICTs as a catalyst. However, ICT use is not, in itself, a useful goal. According to a study by the Organization for Economic Co-Operation and Development (OECD) (in preparation), ICTs can be viewed as neutral, i.e., they may support both effective and ineffective education. Effective plans must include strategic objectives and educational vision to inform the use of ICTs for educational renewal. Leadership and vision are an even more important theme at this transformative level of ICT use in teacher education.

Below is an eclectic mix of illustrations to inform professional development planning at the regional and national levels. The framework is used to analyze the mix of themes and competencies that may be developed by particular strategies at the regional, national and international level.

Collaborative Action Research for ICTs in Pre-service Teacher Education

Project *InTent* was the first national initiative to integrate ICTs into pre-service teacher education. It took place in England between 1989 and 1992, following increasing pressure to prepare teachers before they started practising in schools (Somekh and Davis, 1997). The national association of ICT teacher educators published a survey that identified the lack of resources and support for their work. This was followed by a national commission led by Janet Trotter, a forward-thinking leader of a pre-service teacher education college. The commission's report recommended that the government implement requirements for ICTs within pre-service teacher education curriculum.

Bridget Somekh carefully crafted a proposal. Somekh was an educational researcher with a growing reputation for supporting the development of a community for action research in education. She was also an ICT-using teacher educator, having led a regional project to build learner autonomy with microcomputers. The proposal was built on Somekh's knowledge of the teacher education culture and context of the time. This context included individual teacher educators' dedication to their students and their specific discipline and an increased requirement to research and publish.

This first national programme to integrate ICTs into pre-service teacher education requested proposals. Five different types of institutions in England

were selected to represent the different types of teacher education organizations. Somekh provided leadership and vision and informed the planning and management of change through an approach of action research infused throughout the project.

Each institution was granted the salary of one person for a year, plus travel funding for the institutional team to attend meetings of the consortium each term for two years. Each leader, normally the dean, was required to attend these consortium retreats along with the ICT teacher educators. Periodic visits to each organization by the coordinator provided her opportunities to act both as a leader and a mentor for all ICT teacher educators.

An inclusive learning community developed that supported the adoption of a participative action research approach by all project participants and other stakeholders. The project established and published a special journal series called 'Developing information technology in teacher education.' In this way, the project adopted a collaborative networking approach to organizational development to integrate ICTs into teacher education, and the five institutions reinforced each other's commitment to serve the pedagogic needs of all their colleagues, regardless of discipline or approach to content. There was never any doubt of the aim: colleagues modelling excellent practice with ICTs as they taught methods and content-specific topics. The consortium worked through technical and social issues while integrating ICTs into courses for pre-service teachers, and they supported action research analysis of their own and their colleagues' professional development while planning and managing change.

One particularly innovative approach to support transfer into school-based practice was to bring an elementary class into the primary base at one of the universities. This practice teaching was intensively supported with lectures, equipment, software, and technical support. All the teacher educators and support staff received ICT professional development to facilitate a rich environment of good educational practice. Students were able to practice teaching in pairs with a group of four children. This strategy may be particularly appropriate at early stages of ICT adoption in a region where there are few resources and little ICT practice in local schools.

The national agency and the national professional association supported the dissemination of the project through presentations at conferences and special one-day workshops, journals, and the publication of the final report. In addition to the final report, a series of work cards were produced for specific audiences: deans and department heads, teacher educators, and ICT teacher educators.

They included guidance, quotes from participants, and references to further reading, especially to articles within the special journal. A book on using ICTs effectively in in-service and pre-service teacher education was also edited and published (Somekh and Davis, 1997) and became widely used, especially within graduate courses for ICTs in education.

This first national initiative included all parts of the proposed framework (Figure 2.1), although the focus was on pedagogy. Lifelong learning was modelled through the Action Research approach, which also provided a sensitive approach to the planning and the management of change. The design of project *InTent* was congruent with the context and culture of the time, reflecting the recent government legislation mandate for ICTs and the increasing demands for research and publication. Participants were carefully supported to develop their research and writing as well as to facilitate change. All four ICT competencies were developed in participants and passed on to colleagues. The project addressed technical issues by providing professional development for the supporting technicians and establishing a mandatory introductory course for all pre-service students. The course was taught in content and phase specific groups so that appropriate and pedagogically transferable illustrations could be used and practiced by the students before they used them in the field.

The use of action research accelerated the organizational change in this project, as participants at all levels gathered and analyzed data and reflected on the results. The new government requirement for ICTs in pre-service teacher education provided ample justification for change and an argument for expanding resources in teacher education. The national project leader contributed to institutional development through her research of organizational change, informed by structured interviews of strategically important people. This gathering of evidence was both action and research, because the act of interviewing prompted these people to reflect on ICTs and their place in their organization. It also raised awareness and reflection upon the importance of ICTs in pre-service teacher education and in society.

PT3: A Federal Capacity Building Approach for the USA

In 1999, educators and policy-makers in the United States recognized the growing crisis in teacher retention and recruitment. The need to develop capacity for ICTs in teacher education within universities and colleges was informed by several research studies in teacher education, undertaken by leading ICT teacher educators with support of their professional societies (U.S. Congress Office of

Technology Assessment, 1995). It became clear that the improvement of pre-service teacher education would be an effective use of resources, particularly at a time when schools were losing a high percentage of teachers within five years (over 60% in many regions). A federal programme called *Preparing Tomorrow's Teachers to Use Technology* (PT3, 2001) was established under the leadership of Tom Carroll, a cultural anthropologist with experience in government agencies, including negotiation of the Erate to provide more equitable access to the Internet for poorly resourced schools. Carroll brought together an advisory group of leading ICT teacher educators so that he could better understand the context and culture of their work. Together they developed a national initiative that would build capacity for ICTs teacher education, particularly pre-service teacher education.

The call for proposals the first year announced three types of grant:

- Capacity building
- Implementation
- Catalyst

Capacity building grants provided funding to plan for change, thus increasing the readiness of universities. This category was supported only during the first year of the initiative. Implementation grants supported such projects as the development of models for the exemplary use of ICTs by teacher educators and faculty in colleges of education, in other colleges where students take courses, and in the field experiences of students. Complementary funding was provided in many ways, often through vendors' discounted hardware and software prices, and contributions of time and expertise from within and beyond the universities (partner schools that host practice teaching and the regional agencies for education). The strategy of shared funding required the participants to gain the support of each organization's leadership.

Catalyst grants provided resources to initiatives that were already using ICTs in innovative ways to enable them to share their expertise in building capacity across a large geographic area. Some of the catalyst projects developed high-quality resources to support the infusion of ICTs into teacher education, such as multimedia case studies of ICTs in schools and universities, and software to assist reflective practice, many of which can be accessed on the Internet. Another important catalyst project is development of a digital equity toolkit, which is a growing web site of resources to promote access to ICTs and teaching with intercultural sensitivity (<http://www.digital-equity.org>). The PT3 project that is a national technology leadership initiative (NTLI) aims to develop multiple voices and ownership of the ICT curriculum as it is inter-

preted into the many content areas, especially into the core curriculum of math, English, and science. The NTLI catalyst project hosted the first summit meeting of the professional associations for teacher education in English, math, science and technology. In addition, in collaboration with the only international society specializing in ICTs in teacher education, a new online journal was established to promote discussion and development (CITE, 2002), with autonomy for sections edited by relevant content areas.

The PT3 programme has built regional and national capacity for the planning and managing of change for ICTs in teacher education. Each project was directed to spend at least 20% on evaluation, with an emphasis on evidence to inform the development of the project and provision of summative reports. The leaders of PT3 recognized that organizations needed to learn about the essential conditions for change in their organization and to engineer these conditions (see Sections III and V). Similarly, at the start, many projects were unaware that individual teacher educators were often at an early stage of concern for ICTs.

PT3 leadership formed a national group of evaluators to analyze the changing national picture. Activities have been initiated to develop evaluators' appreciation of systemic change in education. Annual meetings of the PT3 projects provide a community of shared professional development for evaluators of ICTs in teacher education and an opportunity for all project leaders to benefit from ongoing research and evaluation through communication and networking.

The PT3 programme as a national initiative addresses all aspects of the proposed framework (Figure 2.1). Each implementation project targets the development of the four ICT competencies and the catalyst projects support these efforts with additional expertise and resources. For example, one of the catalyst projects is a national centre that promotes collaboration among all major ICT professional society for teachers (International Society for Technology in Education, 2002). This initiative is strongly correlated to the four surrounding themes of the framework. The initiative is embedded in national and local cultures and contexts, with commitment to addressing digital equity, developing capacity for leadership and vision, and for planning and managing change.

South Africa: Building Capacity of an Educational Agency

South Africa, following the break-up of apartheid, provides many challenges for education and an inclusive society. This case study describes a SchoolNet programme established to support educational renewal in some the most challenged

schools in the country. These schools were not closely linked with existing institutions of teacher education; therefore, this case illustrates the establishment of a new agency for reform, rather than the development of ICTs within existing teacher education.

Gerald Roos, an expert ICT teacher educator, created the programme. He had been involved in a variety of ICT initiatives in South Africa and understood the context and culture of teacher education. The SchoolNet programme aims to renew education in rural and minority contexts with multiple African languages and cultures, in a way that will result in long-term benefits for lifelong learners who will become valuable information-literate members of a global community. The context is also of continuing dramatic loss of teachers, influenced both by the upheaval of a society in transition and the AIDS epidemic. The strategy uses the strengths of the Internet to promote ongoing support for teachers to become ICT teacher educators for one another through a mentoring process, facilitated by the central team and external volunteer experts.

The first stage of the programme improved the conditions for successful change. The core team in the agency that was established carefully set a foundation for educational renewal through ICTs. A project website provided a literature review of successful research into ICT teacher training (Educator Development for ICT, 2002). The review was also used to inform policy makers and other stakeholders, including potential participants. Two new strategic documents were also created:

- Key principles of educator development programmers
- Educational strategy for educator development for ICTs (2002).

In the second stage of the project, schools were invited to propose projects for selection and coordination by the agency. The proposals provided the local cultural context and addressed the pedagogical objectives. The agency strategy provided the support to overcome technical issues and to establish collaboration and networking for these geographically separated teachers. Two-day workshops were an important induction stage for these novice teachers and ICT teacher educators, but, as one of the principles states, workshops alone are not sufficient for sustainable outcomes. Those training the mentors addressed a hierarchy of needs, starting with the lowest and ending with the highest, as follows: emotions, technical issues, learning strategies, collaborative planning and mentor. Potential ICT mentors were taken through stages of development in a way that permitted them to reflect on their own ICT professional development, to build their capacity for the mentoring of colleagues. The training took place over the Internet,

supplemented by occasional workshops. Expert mentors from other regions and countries also joined in to support ICT teacher educators in the online community, facilitated and coordinated by the regional agency.

This regional agency continues to play an important role in facilitating digital equity in South Africa by spreading ICT teacher education, informing related policy, and sharing information with local, regional, national and international communities.

Chile: A Model National Strategy Responsive to Culture and Context

The final example comes from Chile, a nation with many economic challenges that has used ICTs to accelerate educational reform. The national ICT initiative is called *Enlaces*. In common with all of the cited examples of good practice, the design was informed and led by ICT experts, and in this case, the team came from a leading university centre, the Instituto de Informatica Educativa of the Universidad de La Frontera. The centre conceived the initiative and has played a central role in the development of the *Enlaces* programme since 1993. In conjunction with the Ministry of Education, it is responsible for the national coordination of the *Enlaces* Educational Network. The Institute also conducts research and development activities to support the use of information and communication technology in the network's schools. The centre was informed by scholarly research in this area, and at least one of the ICT teacher educators undertook a doctoral degree on this topic with leading experts in the University of London Institute of Education. To inform early stages of development and ongoing evaluation the *Enlaces* initiative drew on a wide range of international consultants in ICTs in education, as well as this close doctoral level supervision (Gobierno de Chile Ministerio de Educaciòn, 2002).

The majority of ICT teacher educators in *Enlaces* were drawn from 24 universities, which became known as the Technical Assistance Network. This network was built upon a strategic alliance between the Ministry of Education and universities across the country. The Technical Assistance Network's mission was to train teachers and provide them with technical and educational support. Six universities, designated as Regional Centres, served as coordinators, managing *Enlaces* activities and teacher training in a particular geographical area of the country. They also carried out applied research in the field of educational ICTs. Eighteen universities, called Implementing Units, provided training within sub-zones under the supervision of a Regional Centre.

GOALS AND PRINCIPLES OF THE *ENLACES* PROGRAMME

One of the fundamental premises of the *Enlaces* programme was that merely supplying information technology to schools is not enough to bring about significant changes in the quality of education. Although ICTs can potentially simplify and enhance the learning process in all subject areas and in some cases act as a catalyst for innovation, additional efforts such as teacher training and support – must be done in order to produce sustainable changes in pedagogical practices and student learning outcomes.

The following principles guided the definition of overall strategies:

- Information and communication technologies are tools to be used by all participants in the educational process: students, teachers, school administrators, parents, and sponsors; thus, great emphasis was placed on teacher training and the development of a technical assistance network. The notions that learning computer skills is an end in itself and only experts can use ICTs were rejected.
- The goal is to not only equip schools with computers, but also to connect them with each other and the world through an educational network, thus enabling schools to exchange ideas and experiences regardless of their location. This goal also addresses one of the Chilean Educational Reform's key objectives: increasing equity in educational opportunity for all Chilean students.
- No single formula can be applied uniformly to all schools, and the uses to which computers and networks are put will depend upon each school's educational projects, needs, and social, cultural, and geographical environment.

These considerations, combined with the enthusiasm and initiative of teachers, administrators and students across the country, have often led to surprising results, with broader and deeper implications than those foreseen by the programme.

Enlaces reached 100% of the secondary schools and 50% of the primary schools by 2000 (7 years), thus covering 90% of the school population. Within this group, *Enlaces* created an advanced group of ICT-using teachers in 51 schools from different areas of the country. The schools provided local reference sites to demonstrate ICT practice embedded in the local context and culture. *Enlaces* equipped these schools with more computers, technical support, and pedagogical assistance than the regular schools, with the expectation that they would

become field-based ICT teacher education sites. As a result, these schools formed the core of the collaborative professional development activities that occurred through the Internet. The leading ICT teachers and teacher educators also received international collaborative support from the MirandaNet community of practice, as discussed in the case study.

ENLACES' KEY STRATEGIES

The following were key strategic elements of the *Enlaces* plan to infuse ICTs into teacher education and throughout the educational system:

- **Teacher Training and Support**

The teacher training strategy in *Enlaces* includes three different initiatives:

Initial training over one year helps educators incorporate educational information technology into all aspects their teaching, with special training for one or more *Enlaces* coordinators per school.

Follow-up technical assistance allows the schools to continue the active incorporation of educational technology into their educational projects and to develop greater autonomy in this area.

Educational Information Technology Encounters encourage teachers to exchange experiences and to keep abreast of each other's practices. Students can observe the achievements of their peers in other schools, and the community gains a greater appreciation for the use of technological resources in its schools.

- **National Support Infrastructure**

The Technical Assistance Network was built upon a strategic alliance between the Ministry of Education and universities across the country, with a mission to train teachers and provide them technical and educational support. Twenty-four universities provided national coordinating centres to support six regional centres and eighteen implementation zones.

- **La Plaza: A Non-Intimidating Computer-User Interface**

La Plaza software was created to provide friendly access and a familiar interface to computers. The metaphor is a familiar market square where the images act as icons for each application. For example, clicking on the image of the post office gives access to electronic mail. The software was used to provide a non-intimidating first encounter with

ICT technology. It was particularly successful in reducing teachers' anxiety toward a technology perceived as difficult.

- **Private Sector Support**

The development of the *Enlaces* network required support from the school communities themselves and from the private sector. Expanding the number of computer rooms, acquiring new educational software, servicing equipment, buying necessary supplies and providing Internet connections are ongoing challenges demanding hard work and commitment from the whole community.

Telephone companies in Chile donated telephone lines and unlimited Internet connections to the great majority of the country's primary and secondary schools. In addition, the companies provided free e-mail accounts to all Chilean teachers and students. Numerous primary and secondary schools would not have been able to construct the computer rooms or upgrade computer infrastructure to join the *Enlaces* programme without donations from private companies and contributions from the school communities themselves.

- **Formative and Summative Evaluation**

The results of various evaluations of the *Enlaces* programme between 1993 and 1999 on the impact of ICTs on the educational system showed that there was growth in students' creativity, capacity for gaining knowledge about the world, and reading comprehension levels. Changes in learning levels in the area of mathematics could not be established.

Descriptive evaluation showed that ICTs sparked a high level of motivation among students, produced a more horizontal social organization within the classroom, and made students feel proud of their participation in projects, with a corresponding increase in self-esteem. The evaluations also indicated an increase in teachers' managerial roles and improvements in the internal climate at schools. Furthermore, external evaluations showed that many of the teachers believed that communications via computers in their classes had improved the quality of the teaching-learning process. Two major challenges revealed by these evaluations are the need to supply schools with more computers and a greater variety of educational software, and the concern among teachers about their heavy unpaid workload.

The participating schools gained greater prestige in their communities, which translated into increases in enrolment (increased income

via larger subsidies). School officials also valued the increase in equity that occurred as a result of the project's providing equipment that schools otherwise would not have been able to acquire and the country-wide spread of free access to Internet resources. The project also produced improvements in parents' perception of their schools' performances, which facilitates the learning and teaching process.

From a more global perspective, the evaluations made by the World Bank and the Agency for International Development praise the *Enlaces* project as one of the most successful programmes in Chile's efforts at educational reform. An important point in this positive evaluation is that the project has expanded its coverage to the national level without sacrificing quality or equity. Among the factors in this success, the evaluations mention the programme's focus on teachers, the construction of a social network of educators and pupils facilitated by user-friendly technology and decentralized support, and respect for participating schools' autonomous decisions in the use of the programme's technologies. The evaluations also emphasize the high quality of the project's technical and administrative team, which has maintained a balanced mix of a clear vision, flexibility, and creativity in the face of new educational challenges and fast-changing technology.

DISCUSSION OF ENLACES

An important conclusion that has emerged through observations of the schools is that innovation must arise out of current pedagogical practices. Teachers are more inclined to use technology if they can relate it simply and directly to their class work and to the materials and teaching models they use.

To this end, *Enlaces* seeks to show teachers more clearly the multiple ways in which technology can be used, as much in the classroom as in extracurricular activities. The point is not to merely "do the same thing, only with computers," although in the beginning it may seem that way. The teacher invariably perceives changes in his or her class, at least in the organization and motivation of the students. On the basis of these small initial changes and on clear evidence of the students' improved motivation, the teacher may try out more effective strategies or adapt those of other teachers.

Another interesting observation is that, due to the comprehensive initiative of the Chilean educational reform effort, computers are acting as catalysts for other initiatives that are not directly related to ICTs. Often, in the midst of many

other programmes endeavouring to induce changes in a given school, it is the introduction of computers and telecommunications into the classroom that initiates change. This is not to say that computers by themselves are capable of causing innovation and change; however, they certainly contribute in a substantial way to support the changes envisioned by other initiatives.

The *Enlaces* programme continues to accept new challenges. Its achievements, combined with continuing advances in information and communications technology on a global level, have generated new goals for further expansion of educational information technology in Chile.

The project has adopted a modified cascade strategy to develop large numbers of ICT teacher educators. The central coordinating unit has led the development of workshops and materials to start the innovation, which is informed by their ongoing international research. The centre also leads soft-ware development and national negotiations to support the initiative. The regional centres modified these processes and materials to align with their contexts. They trained the teacher educators in the eighteen implementing units through workshops informed by wider teacher education activities. For example, staff conducted supportive visits to schools seeking the commitment of school leaders and an understanding of their educational objectives. Such visits proved particularly important in the early phases of the project. In late phases, facilitating the growth of online collaborative communication became an important strategy, along with ongoing support to overcome technical and policy issues as they arose.

This case study demonstrates a well-integrated approach when analyzed with the framework in Figure 2.1. The context and culture have been taken into account at each succeeding level: from international to national, then regional, local, and into individual schools. As this was developed, so were leadership and vision, and the continuing showcases and evaluations inform leadership and vision, the planning process, and the management of change. Lifelong learning, with a continuing focus on relevant pedagogy and educational objectives, was maintained within the vision, thus integrating the core competencies. Collaboration and networking were also modelled in the overall strategy.

Private Sector Initiatives in Teacher Educator Professional Development

Intel Corporation has launched an international initiative to provide professional development resources to teacher educators in several countries. The pro-

programme is based on the Intel *Teach to the Future* programme begun January 2000 in the United States. The original programme provided training to in-service teachers on the integration of computer technology into teaching and learning. University faculty who worked with this in-service programme were so impressed by the quality and depth of the pedagogy and materials that they worked with Intel to develop a version of the programme that can be used at the university level with pre-service teachers.

Since then, the materials and curricula have been adapted to thirteen different languages including Spanish, Portuguese, English (British and US), Chinese, Hindi, Japanese, Korean, Urdu (Pakistan), German, Polish, Hebrew, and Russian. As a result, the programme is currently used in teacher preparation programmes in Argentina, Brazil, Canada, China, Costa Rica, Germany, India, Ireland, Italy, Mexico, Taiwan, United Kingdom, and the United States. There are plans to use Intel *Teach to the Future* in eleven additional countries within the next two years.

More information about this programme can be found on the World Wide Web at: <http://www.intel.com/education>.

PHILOSOPHY

The ultimate goal of the Intel *Teach to the Future* programme is to engage elementary and secondary students in culturally and pedagogically appropriate learning experiences that are enhanced by using computers. "The core focus of this curriculum is to ensure that technology is used successfully to improve student learning." Teachers are guided to develop face-to-face, student-centred activities that model effective use of technology for teaching and learning. Faculty members who participate in this programme are recognized as curriculum experts. This programme helps them thoughtfully integrate their pedagogical expertise with computer technology.

DESCRIPTION

The Intel *Teach to the Future* pre-service curricula are designed so that teacher educators and pre-service teachers can use it in a variety of learning Settings. Materials include paper and digital (CD-ROM) resources as well as Web support. Participants learn to use and integrate all three types of resources in their teaching and learning.

Topics covered include:

- Developing and teaching technology-enhanced curricula
- Locating and evaluating web resources
- Copyright and citing of sources
- Designing and creating multimedia presentations, desktop-published products, and web sites
- Designing and creating teacher support materials
- Developing plans for project implementation
- Project development and assessment

Pre-service teachers learn to develop project plans, materials, and examples of student-created materials and presentations. For many teachers this involves a shift in approach from lecturer and expert to facilitator and learner. Examples created by participants are included with programme materials to assist other pre-service teachers as they develop their own plans and resources. Participants are encouraged to adapt these examples so that they reflect their knowledge of their own cultures. As local teachers develop new examples, they are added to the resource packet for their specific country. This adds relevance and role modelling, and encourages collaboration among pre-service teachers, their colleagues, and university faculty.

APPROACHES

As they progress through the programme, pre-service teachers build on their existing technology skills, developing them as they develop their curricula. The central focus of this curricular approach is project planning. Working with a professor, who serves as facilitator, pre-service teachers develop project plans for elementary and secondary students that emphasize active learning and collaboration. Teachers are encouraged to develop learning activities that take advantage of the unique aspects of computer-based learning, such as creating interactive multimedia presentations and publications.

Using this approach, pre-service teachers are developing their own technology skills in an embedded and relevant way. For example, a pre-service teacher completing the programme will have achieved 85% of the skills required for the European Computer Driving License, but will have learned these skills as they relate to teaching and learning in the elementary and secondary classroom. They

draw on their knowledge of their culture, language and curriculum to make sure that these activities are culturally appropriate and fit the overall goals of their education system.

HOW IT IS USED

One of the key elements of this programme is the view of faculty as curriculum experts. Participants begin by learning how to use the computer applications they will integrate into their programme plans. Then they identify a subject or concept they plan to teach and develop a project plan that integrates the use of computer technology. By starting with a topic they are familiar with, participants are better able to focus on identifying and developing resources and activities that serve as models of engaging learning activities for children. This familiarity leads to greater success and understanding of both technology and programme planning.

As they develop their project plans, participants also develop the curriculum materials they will need to teach their lessons, resources that their students will use, and model examples of the projects their students will be creating. This provides faculty and pre-service teachers authentic experiences using technology and helps them better understand the processes and challenges their students will encounter when implementing their projects. Throughout this experience, participants share their ideas and plans, discuss how they will assess student learning, and develop alternate activities so that their lessons can be used with a variety of students and settings. This reflective approach to teaching and learning further assures that pre-service teachers enter the classroom with the knowledge and skills needed to successfully integrate technology into culturally appropriate learning activities.

The modular approach of this curriculum allows teacher education faculty to adapt it to their specific university programme. The full curriculum could be embedded in a single course, spread out over several courses, integrated into internship experiences, or some combination of all these. To provide the greatest benefit, faculty who use this curriculum should be teacher education faculty who model the effective use of technology for teaching and learning as they teach the pedagogy of subjects. This helps pre-service teachers make the cognitive connections they need to further understand the teaching and learning process, and gives them the knowledge and skills they need to be effective educational leaders in their classrooms and schools.

KEY LESSONS LEARNED

The following lessons learned are congruent with the framework in Figure 2.1 and may be helpful to other private sector or international organizations interested in providing professional development programmes or resources to universities or educational systems in other countries:

Infrastructure: Don't wait for it to be perfect—press on with what you have and make the most of it.

It is important to prepare teachers who can take advantage of new technologies as they become available. One of the biggest challenges to this is the lack of infrastructure and connectivity to support teaching and learning with computer technology. However, as the price of technology drops and schools begin to invest in computers, those challenges are beginning to disappear. Because the curriculum is adaptable, teachers are able to immediately use resources they do have, and implement the project plans that they develop. This allows them to effectively use the resources that are currently available to them, while gaining an awareness of the newer technologies that will soon be available. As a result, these teachers often become advocates for change and leaders within their own schools and programmes.

Policies: Universities and Ministries of Education must work together for change.

In some countries the responsibility for preparing new teachers lies outside the Ministry of Education, creating a barrier for implementing change throughout an educational system. Despite this, Ministries of Education have indirect power over universities and can influence teacher education curricula. The Ministry often decides who gets hired, what skills new teachers should have, and where new teachers will work. By providing this curriculum as a model, Ministries of Education can help guide the preparation of technology-using educators and assure that all the children in their country have the benefit of technology-enhanced curricula that have been adapted to fit their language and culture.

Systemic Change: University faculty are critical to improving the system.

It is often difficult to get support for change from all university faculty. They tend to be the most critical, understanding the implications of change and showing concern for honesty and accountability. They

also tend to be good leaders for teachers in elementary and secondary schools, and share their insights through scholarly writing. By focusing on faculty who adapt and adopt this change to teaching and learning, universities and Ministries of Education can successfully implement change while maintaining a healthy scepticism that assures new curricula are culturally appropriate. When teachers adapt and adopt this curriculum they, too, become advocates who help promote systemic change.

Online Content: Teachers and students can be important developers of good educational content.

Providing students with high quality Internet resources in their own language has been a problem in the past. Fortunately, non-English language sources are improving and increasing, giving teachers throughout the world the opportunity to integrate these resources into authentic learning experiences for their students. As more teachers in a country participate in this programme, the quantity and quality of online resources will increase.

Cultural Differences: Take materials from the US, UK and Germany and adapt them to work in other regions.

The terminology that educators use to describe the planning process varies from country to country, but the concepts are much the same. For example, the Essential Questioning technique developed by Wiggins and McTighe is often used in the United States, along with the concept of goals and objectives. No matter what terminology is used to develop a programme plan, teachers must know what they want their students to learn as a result of the experiences they are planning. Helping teachers to understand the planning process and to adapt their plans to the context of specific students will help teachers move beyond the limitations of terminology to a better overall understanding of the teaching and learning process.

Subject: Teachers vs ICT Teachers.

Who teaches the curriculum is also an issue. For effective integration to happen, this curriculum needs to be adopted by methods and pedagogy teachers, not just computer and technology teachers. It is not about the technology. It is about how technology supports teaching and learning.

Time for Professional Development and Training.

Faculty and teachers who participate in Intel *Teach to the Future* often give up their own time outside work to be a part of this programme. In doing so, they become role models for lifelong learning. This impacts all levels of learning: faculty modelling for pre-service teachers, and teachers modelling for children.

Adapt and Adopt: Make it work for specific regions.

English language and American culture are not always appropriate in other countries. It is critical that teachers have examples of curricula that are in their language and are culturally appropriate for their students learning styles. When the Intel *Teach to the Future* programme is first introduced into a country it comes with curriculum samples from the United States. Examples of technology enhanced programme plans that have been created by faculty and teachers in the country are added to the programme as they are created. This gives each country the opportunity to develop its own set of resources that are both developmentally and culturally appropriate. Encouraging more of a country's educators to use this curriculum will greatly increase the resources that are available in its language and culture.

It is important for faculty and pre-service teachers to see beyond the vocabulary that describes technology and its use and move toward an understanding of the philosophical approach of using technology for teaching and learning. The Intel *Teach to the Future* curriculum goes beyond rote learning and challenges both teachers and students to think. If a student can answer a question by cutting and pasting a response, then it is not a good question. This programme challenges faculty and teachers to think about how children in their country and culture best learn, and develop appropriate technology-enhanced activities to assist them with the learning process.

Quality Assurance: Formative and Summative

The case studies described above had an eclectic mixture of strategies to assure quality, both within the developmental process and in summative reports. These can be categorized as academic quality assurance, common in universities and colleges, and project evaluation approaches including research. The majority of the case studies have used both of these types of quality assurance. The mix of approaches include:

- Teacher educators, both expert ICT project leaders and those receiving ICT teacher education, studying under university supervision and in courses in higher education, have the quality of their work assured through assessment and grading.
- Annual reviews, now common in higher education, assess the performance of teacher educators. Internal policies are moving to encourage the inclusion of ICT use as a criterion of quality teaching. Similarly, courses and degree programmes have associated mechanisms for quality assurance, including peer review by visiting teams of experts.
- A peer review process evaluates research, including action research, as it proceeds into academic publications.
- Formative evaluations are usually conducted by project teams and collaborating evaluators, and are particularly valuable in informing project management and for dissemination among the participants and other stakeholders.
- Funded projects at all levels—from local internal university programmes to support project leaders to international evaluations carried out on behalf of organizations such as the World Bank—are required to have summative project evaluations.

Combinations of approaches to quality assurance are also recommended. Summative and formative evaluation may be particularly successful when used together with action research. For example, a multinational European project to develop ICTs in teacher training across the European Community had evaluation activities that focused on case-based reasoning and included data collection through various instruments from all stakeholders. Wim Veen, the leader of the evaluation team, described the T3 approach to evaluation as follows:

A 'multi-perspective illumination' approach (Parlett and Dearden, 1977; Melton and Zimmer, 1987) was adopted focusing on the emerg-

ing new teaching practices within the participating teacher education institutions. The evaluation effort focused on:

- Formative evaluation of the development and implementation of the new teaching practices using Telematics (ICTs) within the partner universities involved, and
- Summative evaluation of outcomes and impact of the project as a whole and of the development of pedagogical approaches for Telematics learning environments. (Davis, Hawkes, Heineke and Veen, 2001, p. 52)

The variety of stakeholders who must be considered for evaluation includes those whose involvement and co-operation were necessary for the project to succeed, as well as those who are expected to use or act on the evaluation results. Different stakeholders have different questions relevant to the interest they take in the initiative. They also have different views about what is useful and feasible and how success is to be defined. For T3, the recognized stakeholders included the teacher trainers involved, the students and collaborating colleagues, and the sponsoring partners, including the funding agencies and those who provided resources in kind (time, equipment facilities etc.).

Just as the application of ICTs to teacher education must consider the culture and context, so, too, must evaluation. The development of capacity for evaluation of ICTs in teacher education was described in the PT3 case study. The T3 evaluation also started with a review of the stakeholders. It was known that expert ICT teacher educator participants would carry out their own action research, occasionally informed by doctoral degree studies. The T3 project evaluation team then adjusted their plans to focus their activities on three domains of interest:

- To improve performance by helping project partners develop mutual understanding of useful applications of Telematics at specific teacher education institutions, while identifying generic uses of Telematics in teacher education across Europe.
- To help project partners implement the results of their efforts both within their institutions and among the T3 partners. In this case, evaluation activities focused on strategies and experiences of implementation and on dissemination of results outside the project partners.
- To contribute to the overall learning process within the T3 project that would be useful for future projects and initiatives. (Davis, Hawkes, Heineke and Veen, 2001, p. 53)

Initiatives to develop ICTs in teacher education should also adopt this sensitive approach to both formative and summative evaluation. Evaluation teams should aim to involve as many of the stakeholders in the evaluation process as possible, particularly project participants, and the evaluation team should coordinate these efforts to inform project management and promote dissemination locally and to funding agencies.

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VI.

DEVELOPING THE STRATEGIC TECHNOLOGY PLAN

This section describes the technology planning process and provides strategies and resources for developing the components of plans for integrating ICTs into teacher education programmes. The development of the technology plan involves three phases, including:

Organizational Phase: The Technology Planning Team is formed with representatives from key stakeholder groups. The scope of work is determined and the planning tasks to be accomplished are identified.

Assessment and Analysis Phase: An analysis is made of the present situation including the present level of technology knowledge and skills of teacher educators, the teacher education curriculum and performance results, national teacher technology standards, condition of teacher education facilities, and the current technology resources and infrastructure within teacher education programmes or institutions. A powerful vision for ICTs in teacher education is developed focused on improving teaching and learning. Specific goals and objectives are developed to achieve the vision.

Formulation Phase: Based on the vision, goals and objectives, a technology plan is developed including standards and models for technology and learning, hardware and software requirements, staff development plans, technology support services to be provided, facility improvement requirements, project timelines, areas of responsibility, and a detailed budget. These items are integrated into a comprehensive technology plan that is submitted for review and approval.

The sequence and relationship of the tasks involved in developing the technology strategic plan are shown in Figure 6.1.

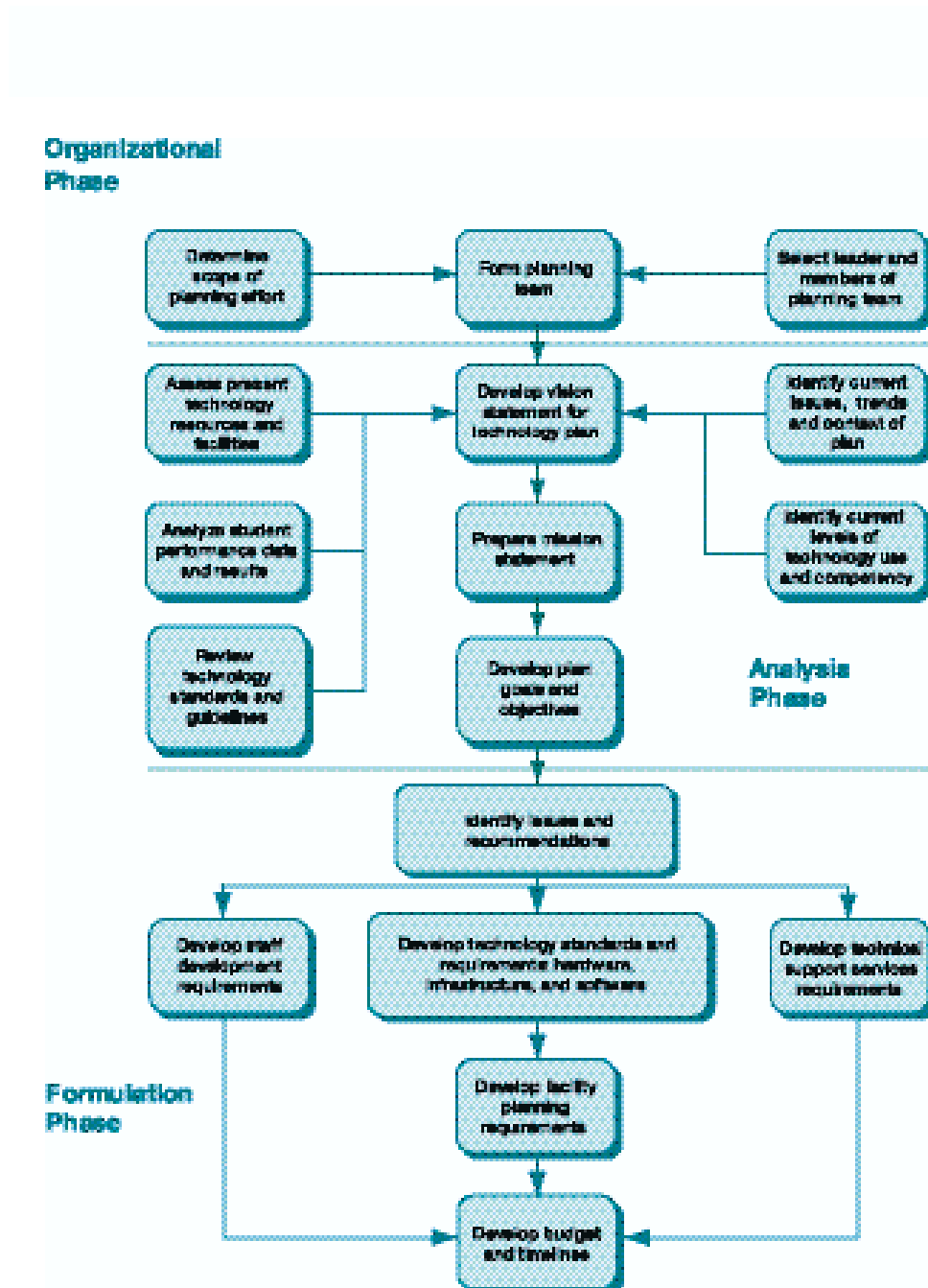


Figure 6.1 Phases of Technology Planning Process

ORGANIZATIONAL PHASE

The organizational phase of the development of the technology plan involves the following activities: selecting the team leader, forming the planning team, determining the scope of the planning effort, and identifying the budget and time constraints for completion of the plan.

Select the Planning Team Leader

It is important to select a qualified person to lead the planning effort. The person should be chosen by the chief executive of the institution or government organization responsible for the development of the plan. The person selected should have the commitment and support of the organization's highest administrators, and have high credibility in the organization as well as with teacher educators and other important stakeholder groups (e.g., K-12 teachers and administrators, business leaders, community representatives who would be interested in or affected by the technology plan). The person selected need not be a technology expert, but should be someone who understands the potential of technology to improve education and has the communication, management, and interpersonal skills to lead the team and communicate with stakeholder groups in developing the plan.

Select Members of the Planning Team

The members of the team should be chosen carefully because it is important to establish a team that has the commitment, leadership, and needed expertise in teacher education, ICTs, and K-12 education. The planning team should be composed of individuals from the teacher education institution or agency developing the plan and representatives from external stakeholder groups. The team should include teacher educators, administrators, pre-service and in-service teachers, and members of other key stakeholder groups who will be affected by the plan. If the plan is developed within an institution of higher education, it is also important to have representation on the team from university computing services and other units in the institution that offer courses taken by students in the teacher education programme. The team should also include members who can contribute resources or expertise to the plan or whose support will be critical to the plan's acceptance. Ultimately the commitment, expertise, and perspectives of the planning team members will determine the quality of the plan. It is often helpful for members to engage in team-building activities to get to know

each other and become familiar with the rich range of expertise and diverse perspectives that exist within the team.

Determine the Scope of Work

As a first task, the team must understand the scope of work, timelines, and budget constraints for developing the technology plan. In determining the scope of work, it is helpful to address questions such as:

- What are the expectations of the planning team?
- What is the prescribed deadline for completion of the plan?
- What funding or budget resources are available to support the planning effort?
- Is the plan driven by a particular need?
- What technologies are to be covered in the plan?
- Is the planning national or regional in scope or for an individual institution's teacher education programme?
- Is it to be a one-year or multi-year plan?

Answers to these questions will help the planning team define the scope of work based on a shared understanding of the assumptions, expectations, resources, and constraints of the planning effort. On the one hand, it is important not to define the scope of work too broadly or to attempt more than can be accomplished within the time and budget constraints. On the other hand, defining the scope too narrowly may result in the planning team over-looking or underestimating the possibilities.

It is critical to understand the deadline for completion of the plan and to set milestones and timelines for completing each component of the plan. Planning always takes longer than expected, because a critical and time-consuming aspect of the planning process is building consensus on critical elements among the team members and stakeholder groups. It will not be possible to achieve consensus on every aspect of the plan, and at times the planning team or planning leader may need to make final decisions on specific plan elements.

ASSESSMENT AND ANALYSIS PHASE

The second major phase of the planning process is the Assessment and Analysis Phase. In this phase, the team will determine the present status of ICTs in the teacher education programme or institution that is the focus of the planning effort. This involves assessing the status of ICTs in teacher education and developing a powerful vision of learning with technology. The planning effort may be thought of as a journey or a quest. Before setting out on this quest, it is necessary to know the state of ICTs in teacher education at present. The vision describes the destination or desired state of ICTs in teacher education in the team's country, region, or institution. The plan serves as the 'road map' to help the programme move from the current state to the desired state (i.e., the vision).

The major tasks of the Assessment/Analysis Phase of the planning process include:

- *Understanding current trends in the application of technology to learning.* What are national and international trends in technology use as a tool to enhance learning?
- *Assessing the present status of the teacher education programme related to technology and learning.* To what extent is technology integrated into the curriculum and instructional practices of teacher educators?
- *Examining student performance results.* What is the level of technology knowledge and skill of graduating teachers? What areas of the curriculum need improvement? Can technology be used to address curriculum needs?
- *Assessing the technology resources and facilities currently available in the teacher education programme.* What is the level of access to technology in the teacher education programme?
- *Identifying current levels of technology use and competency of teacher educators.* What are the present levels of knowledge and use of technology by teacher educators?
- *Reviewing national, provincial or state standards for student and teacher technology competency.* What are the desired levels of pedagogical and technology knowledge and skills of teacher educators and teachers?
- *Identifying teacher educator technology training and technical support needs.* What professional development is needed for teacher educators to

develop needed competencies? What technical support is required for them to use technology in their instruction?

- *Developing a plan for communicating with stakeholders.* Who are the key stakeholders in the technology plan and what are the most effective ways of communicating with them throughout the planning process?

Understand Current Issues and Trends

In order to understand the teacher education programme's current situation in relation to the national or international continuum, it is helpful to look at current issues and trends in the integration of ICTs into teacher education at the national and international level. The 'New Economy,' whether described as the information economy, digital economy, or knowledge economy, has produced significant changes in agriculture, industry, business and many other aspects of global society. It is also beginning to change our educational institutions and the teaching-learning process. It is important to understand what it takes for technology to improve learning. In developing the plan, consider the following conditions that are essential for schools to derive the full benefits of the new tools for learning:

- Teacher educators, teachers, and students have meaningful access to technology.
- Internet and communication capabilities are available to access libraries, museums, locally, nationally, and around the world.
- High quality content is available for the classroom.
- Teachers understand and know how to use the ICT tools for learning.

Much is now known about how humans learn, and this knowledge needs to be considered in determining how technology can best be used to create new and more powerful learning environments. Understanding current issues and trends in learning theory will provide the planning team helpful information for developing its vision of ICTs in teacher education.

Assess Present Status of ICTs in Teacher Education

It is important early in the planning process to determine the level of accessibility of ICTs in the teacher education programme and the extent to which technology is integrated into the curriculum and instructional practices of teacher

educators. The *StaR Chart for Teacher Education*, developed by the CEO Forum (2000), provides a tool that may be used to identify the current technology profile of the teacher education programme and to set goals and provide benchmarks for integration of ICTs into the programme. The chart ranks teacher education institutions into four categories:

- *Early Tech* teacher education programmes have limited technology resources and infrastructure. Most of the available technology resources are 5+ years old. The programme receives less funding than other campus programmes. There is limited partnership with schools for technology. There is limited technical support and less than 25% of the methods and content courses integrate technology into the curriculum. Most teacher educators are at an early adoption stage in using technology and have had little or no technology training.
- *Developing Tech* teacher education programmes have some clear goals and the level of funding for technology equals that of most higher education programmes. Technology is integrated into 50% of the courses and in the field experiences of students. Funding is about the same as other programmes on campus and there are growing investments in technology. The equipment is 3–5 years old. The teacher education faculties are either at the adoption or adaptation level in using technology with 75% using technology in their teaching practices. The institution rewards expertise in using technology in teaching and research. In addition, technology training workshops and technical support are provided to the teacher educators.
- *Advanced Tech* teacher preparation programmes are focused on continuous improvement of the programme. Funding for technology equals the top 2–3 programmes on campus and technology is integrated into most of the courses and into 75% of the field experiences. The teacher educators are at the adaptation or appropriation level in understanding and use of technology to enhance learning.
- *Target Tech* teacher education programmes integrate technology throughout the curriculum and into all teaching practices. Students and teacher educators use current digital resources both in the classroom and online. Pre-service and in-service teachers and teacher educators use digital means to communicate with each other and with experts locally, nationally, and globally. All graduates meet the highest standards of technology teaching expertise, are sought after for these skills, and become technology leaders in their schools.

ICTs in Teacher Education Benchmarks and Self-Assessment Tools

In planning to integrate ICTs into teacher education, it is important for teacher education institutions to understand types and levels of knowledge and skills needed for teachers to effectively use ICTs in instruction. They must also understand the level of readiness of the institution to integrate technology into the teacher education curriculum. The teacher education programme or institution must know the benchmarks, standards and guide-lines for ICTs in teacher education. It is also important that they have access to tools that help the institution assess its level of readiness or progress toward infusing ICTs into the teacher education programme. A number of tools may be used as developed, or adapted as needed, to help the technology planning team assess the level of technology integration in their teacher education programme prior to developing plans for integrating ICTs into the curriculum. The tools will help determine the teacher education programme's current level of readiness by addressing the following questions:

- What are the technology resources and facilities currently available in the programme?
- What is the level of technology knowledge and skills of faculty and staff?
- What are the available staff technology training and technical support resources?

As shown in Table 6.1, there are a number of web-based tools available to help the planning team or teacher education institutions assess their progress in incorporating ICTs into teacher education. As noted in the table, some of these tools are specifically for teacher education programmes and higher education institutions while others are designed for assessing technology integration or level of readiness for technology in K-12 schools. The K-12 profile or survey instruments have often been used or customized to yield information that is useful for assessing the status of technology infusion in teacher education.

Several of the assessment tools listed on the table are web-based and allow for online form submission and the automatic analysis of responses. Teacher educators may use some of the tools to provide a profile for self-assessment of technology use, knowledge, and skills. Other tools are designed to provide a profile for an entire school, college, or teacher preparation programme and may serve as useful indicators of the present level of readiness for the integration of technology into the programme. Many of the forms may also be used in a paper-pencil mode if desired.

The Edmin TechBuilder (2002) represents a suite of tools and a database specifically designed for acquiring and analyzing information for the development of a technology plan. Although designed for K-12 schools, the tools can be used by teacher preparation institutions to develop a comprehensive technology plan.

TechBuilder provides standardized multiple-choice surveys that can be completed online by teachers and staff. This information can be used to gain a better understanding of such questions as:

- What technology is currently used in the college?
- Where is technology being used?
- How is technology being used?
- What is the current level of staff knowledge and training?

Because information is stored in a database and analyzed in real time, it is possible to review results immediately. A sophisticated reporting engine identifies an institution's specific areas of strength and weakness and shows progress through presentations, charts, and graphs.

Other tools listed on the table that may be helpful in assessing the present situation in technology integration include:

- **PT3 Profiler**

The PT3 Profiler is a tool developed by the SCR-TEC at the University of Kansas (2000) in the United States. It includes a Basic Technology Survey that can be used by teacher educators for self-assessment of technology integration knowledge and skills.

- **Targets for Technology Integration in Teacher Preparation**

Targets for Technology Integration in Teacher Preparation is a tool developed at the Technology Leadership Academy at the University of Texas at Austin to assist teacher preparation programmes in monitoring progress toward technology integration. It provides descriptive indicators for each target. To use Targets for Technology Integration as an institutional self-assessment tool, one or more members of the faculty or administration complete the survey indicating their best estimate of their institution's status in each of the target components. After completing the survey and clicking on the "submit survey" button, they

can then view the survey results along with an aggregate profile of all of the respondents from the teacher preparation programme (SCR*TEC, 2000).

Table 6.1 Tools for Assessing Integration of ICTs into Teacher Education

Assessment Tool	Designed for Higher Education?	Web Delivered?	Profile Provided?
For Institutions of Higher Education			
Higher Education Information Resources	Yes	No	None provided
CEO Forum StaR Chart	Yes	Yes	Single respondent
For Teacher Education Programmes			
CEO Forum StaR Chart	Yes	Yes	Single respondent
Edmin Tech Builder	Adaptable	Yes	Multiple respondents
SCR*TEC Profiler-System-wide Tech Implementation	Adaptable	Yes	Multiple respondents
SEIR*TEC Survey	Yes	Yes	None provided
For Teacher Educators			
SCR*TEC Profiler	Adaptable	Yes	Multiple respondents
Edmin Tech Builder	Adaptable	Yes	Multiple respondents
Milken Exchange Professional Competency Online Assessment Tool	Adaptable	Yes	Single respondent
NCREL Technology Profile Tool	Adaptable	Yes	Single respondent
For Pre-Service Teachers			
TLT Flashlight Current Student Inventory	Yes	Yes	Multiple respondents

- **Learning With Technology Profile Tool**

This tool helps teachers compare their current instructional practices with a set of indicators for engaged learning and high-performance technology. The tool was developed by the North Central Regional Educational Laboratory (NCR*TEC, 2002) for use by K-12 teachers but may also be used, or adapted for use, with teacher educators to help them assess their current instructional practices.

- **The Milken Professional Competency Continuum (PCC) Online Assessment Tool**

The PCC online assessment tool was developed primarily for K-12 teachers but is potentially useful for teacher educators. Developed by The Milken Exchange on Educational Technology, the tool provides educators with an opportunity to assess their status within the skill and knowledge areas described in that continuum (Milken Foundation, 2002).

- **Flashlight Current Student Inventory**

The Flashlight Current Student Inventory gauges and archives college student use and mastery of technology. Developed and distributed by The Teaching, Learning, and Technology Group (TLT), the tool helps faculty participants design customized web-based questionnaires from hundreds of self-rating and open-ended questions on student background, use, experience with technology, and satisfaction with course experiences (TLT, 2002).

Use of the above assessment tools can help teacher education institutions assess their present status and levels of readiness to integrate technology into the teacher education curriculum. These tools can also help the planning team establish benchmarks and monitor the progress of the implementation of the plan.

Examine Student Performance Results

The goal of technology infusion in schools is to improve student learning. One of the first tasks in the development of a technology plan is to identify the strengths and weaknesses of current teacher education programmes.

One way to determine teacher education programme performance results is to examine the data from exit assessments, certification tests used for grad-

uating teachers, or other relevant data. It is important to determine the knowledge and expertise of teacher education students in using technology in instruction. This may be done in various ways such as by observing pre-service or in-service teachers using technology in instruction, by examining electronic portfolios of students' academic work, or by examining technology competency evaluations by supervising or mentor teachers.

Looking at the summaries of student performance data of the K-12 schools that hire the teachers also helps to identify areas that require improvement. Performance tests, final exam results, and dropout rates during the past two years may give a picture of the academic areas that are strong, as well as those that may require further improvement. It is also important to look at performance by gender, economic disadvantage, ethnicity, etc., to see if there are important discrepancies that need to be addressed. For those curricular areas needing improvement, consider how technology may help address the instructional need. For example, an international study of eighth grade mathematics (NCES, 2000) showed that middle school students using open-ended, problem-solving software significantly improved mathematics performance. Similarly, a number of technology tools and programs can help improve learning in science. Research also shows that technology can help improve writing, the learning of social sciences, foreign languages, and other elements of the curriculum.

In examining student performance data, it is important to assess the technology knowledge and expertise of graduating teachers in using technology in instruction. One way to do this is to ask pre-service teachers to compile an electronic portfolio of their work that demonstrates specific technology competencies.

Assess the Technology Resources and Facilities Currently Available in the Teacher Education Programme

Before the technology plan can identify what new or additional technology resources or facilities are needed to provide the desired learning environment in the teacher education programme, the planning team must first know what resources exist in the school and how those resources are used.

To determine a school's technology resources it is important for the team to review or develop a complete inventory of the existing hardware and software within the teacher education institution. Existing inventories may be used for this purpose or the institution's inventory control or technical

staff may prepare summaries of the types and quantities of hardware and software used in teacher education. In looking at the hardware inventory summary data, the planning team must determine not only the level of access to technology by teacher educators and students, but also the age and capabilities of the technology. For example, older computers may not have sufficient capabilities to access Internet resources. The team should also look at the technology infrastructure and determine the type and level of connectivity available to teacher educators. Is access limited to only a few phone lines? Is there broadband access for viewing graphics and video on the Web? What software is available for use in the teacher education programme? Does it reflect high quality and culturally responsive content? What software programs are most frequently used in teacher education? Answers to these questions are needed to develop an accurate picture of the status of the use of ICTs within the teacher education programme.

The type and condition of facilities in which the technology is to be used must also be carefully assessed. Questions to be addressed by the planning team include:

- What facilities are available to support the plan?
- Does the facility have the electrical wiring and infrastructure necessary to support a significant increase in personal computers and servers? Will this be the first capital expense?
- What is the state of the buildings used by the teacher education programme, and how easily can the wiring required for networks be installed?
- Which buildings and what rooms will be connected?
- Do the buildings have the necessary air conditioning and room security systems?
- Is there physical space for routers, hubs, servers, CD towers, and other key network equipment?
- Is the university or teacher education institution planning on constructing new buildings? New facilities can be built in ways that reduce the cost of technology adoption later on; for example, incorporating appropriate wiring or at least wiring ducts in new buildings greatly reduces the cost of adding technology later.

The Higher Education Information Resources Alliance has developed a set of guidelines that colleges and universities can use when conducting

institutional self-assessments of their technology facilities and resources. The Evaluation Guidelines for Institutional Information Resources are available at their web site (Higher Education Information Resources Alliance, 2001).

Review National, Provincial or State Technology Competency Standards

The assessment of teacher educator technology competencies should be based on the national, provincial or state standards for teacher technology knowledge and skills. The standards are efforts to identify the core knowledge and skills necessary for teachers to effectively use ICTs to enhance learning. If standards for teacher technology competency do not presently exist, it is helpful to look at standards for student knowledge and skill in using technology. These standards may be helpful in considering the core technology competencies also needed by teachers. It may also be helpful to view teacher technology standards used by other countries. As noted in Section III, the International Society for Technology in Education (ISTE) NETS Project is one example of a set of technology application standards for teachers. The NETS Standards for Teachers are found at the ISTE web site (ISTE, 2002). The NETS have been used in the United States and have been adopted or adapted by a number of other countries to meet the needs of their educational systems.

Identify Current Levels of Technology Use and Competency of Teacher Educators

In establishing a baseline for the technology plan, it is important to understand the present levels of technology proficiency of teacher educators in the teacher education programme. This may be accomplished by encouraging the use of self-assessment instruments such as those presented in Table 6.1. To obtain honest responses, it is often helpful to have the survey forms completed anonymously. Other means of assessing the present levels of integration of technology into the pre-service programme may include interviewing teacher educators on their use of technology, reviewing course syllabi for evidence of technology use in the course, and observing the level and type of technology use in the programme classes.

Identify Teacher Educator Technology Training and Technical Support Needs

ICTs represent new tools for many educators and there is ample evidence that providing teachers or teacher educators with technologies without training or technical support results in poor or limited use of ICTs to enhance the learning environment. As part of the analysis, it is important to understand the technology training that has been previously provided to teacher educators. Based on the assessment of the present levels of teacher educator knowledge and skill in using technology, the planning team can better determine the professional development needed to help the teacher educators develop the desired competencies. It is also important to determine the present levels of technical support provided to teacher education faculty and to identify the level and types of support needed to facilitate increased and effective use of technology in instruction.

Communicate with the Stakeholders

In developing the technology plan, it is important to keep stakeholders informed throughout the entire planning process by sharing information on the current situation of ICTs in teacher education, the identified needs, and the vision, mission, and objectives of the plan. It is also important to get input from all stakeholders to help build support and advocacy for the technology plan. Many impressive technology plans have failed because of the lack of effective communication with key stakeholder groups. Consequently, a critical element for the success of a planning effort is to develop an effective communication strategy. Such a strategy will:

- enhance consensus-building efforts by keeping everyone informed;
- attract potential business and community partners to the university or school;
- help attract in-kind contributions in support of the plan.

In a very real sense, the members of the planning team must also become effective communicators to stakeholder groups. As the team progresses through the planning process, they should meet with key stakeholder groups and determine the potential strengths and barriers to the plan's implementation. The emerging plan may then be modified to address concerns or obstacles, and the team can tell stakeholders how these concerns will be addressed.

The communication strategy may involve meeting with university administration, faculty, students, K-12 school administrators and teachers, national,

state, or provincial educational agencies, business leaders, and community, civic or international organizations. Having "town halls" on local TV or radio stations and developing a brochure on the plan's vision and goals are also important. It may be possible to solicit the volunteer services of local marketing or advertising firms to serve as consultants in developing a communication strategy. As the team approaches this task, it is important to ask:

- Who are the major stakeholders in the teacher education programme?
- What are their interests (political, economic, personal) in the programme?
- How will the stakeholders be sampled?
- How will the team communicate with the stakeholders?

Answers to these questions will help guide the development of an effective strategy to communicate with those whose commitment and supports are vital to the plan's success.

Analyze and Report the Assessment Data

Once the comprehensive assessment is completed, the planning team must make sense of the different types of data and interpret what it says about:

- The progress made by the teacher education institution in the infusion of technology into the instructional and administrative processes;
- The technology resources and facilities currently available to the teacher education programme and how and to what extent they are used in the content and methods courses;
- The levels of staff technology expertise and training; and
- The areas reflecting local and national priorities that need immediate, concerted attention for improvement. It should be made clear how technology may help address the priority areas.

The results of the assessment should be summarized in a form that is easy for others to understand and should establish a clear picture of the present state of ICTs in the teacher education programme. The report should provide a brief description of the procedures used for the acquisition and analysis of the data and a concise presentation of the findings. In addition, it

should provide a summary interpretation of what the results indicate about the level of infusion of technology into the teacher preparation programme.

Develop the Vision of ICTs in Teacher Education

Knowing the current situation of ICTs in teacher education, the next step is to develop the vision statement that will serve as the focus of the strategic technology plan. A vision statement is the grand, global statement around which a teacher education institution will be focused for action. It is the most important part of the strategic technology plan and will guide the development of all of the elements of the plan. It describes a set of ideal circumstances that the teacher education programme will strive to achieve. The vision statement should provide:

- a clear and concise statement of the team's vision for using technology to improve learning and teacher education;
- an indication of who will use the technology and how it will be used to enhance learning;
- an indication of the envisioned benefits that will result from the use of technology by pre-service or in-service teachers, teacher educators, administrators and others.

The plan's goals, objectives, and implementation activities must tie back into the vision statement. The vision statement should be used to check the validity of any goal or activity specified in the strategic plan. For example, if the plan specifies the creation of interactive distance learning classrooms in the teacher education institution, the reason for creating those classrooms should be implicit in the vision statement. In this example, such a reason might be reflected in a statement such as "We will use technology to bring knowledge and new experiences from around the world to all of our pre-service teachers." The vision statement is the one place where the purpose and intent of educational technology come together.

If the vision is to become a reality, careful planning, time for reflection, and adequate resources are imperative. The vision statement of the technology plan should be focused on learning and provide a clear idea of how the vision will help prepare a new generation of teachers who are able to effectively use the new and powerful ICT tools for learning.

There are two approaches for developing a vision. In one approach, the vision is developed prior to identifying the teacher education programme's status in integrating technology into the learning process. The advantage of this approach is that it often leads to creative visions that are not constrained by the realities of the current resources and context. The other approach involves developing the vision after a careful assessment of the status. The advantage of this approach is that it may result in a more "doable" vision. Arguments can be made for either approach and the planning team must decide which approach to use. In using the latter approach it is necessary to let go of "what is" and reach for "what should be" in teacher education.

The vision statement should address the question "What do we want teacher education to look like in three to five years?" Five years is the recommended time frame of a long-range vision. If the time frame is too close to the present, the thinking will tend to pull to the current status of technology in teacher education. If the time frame is too far into the future, it may seem that the goal is unattainable and thinking can get sidetracked.

It is important to understand the difference between strategic planning and visioning. Strategic planning is combining what is known today with lessons learned from the past to develop a plan to set and accomplish the vision, mission, goals, and action plans of the teacher education programme. Visioning is about conceiving a desired future state, a picture of where and what the teacher education programme should be in the future, without being constrained by such factors as funding or resources, and then working backward to develop an action plan to get there. It is about imagination and discovery, not simply analysis and forecasts.

Vision represents the following characteristics:

- *Visions are grand and exciting.* Visions inspire and challenge the organization and its members. They capture the imagination. Little visions are not worth committing years to create, but a grand vision is something everyone can understand intuitively, take pride in, and work towards. Such visions can be the single most powerful influence on an organization's destination. Successful technology plans are driven by vision; they are not driven by a chain of command.
- *Visions focus on the end state.* Visions can act like internal gyroscopes, directing individuals and their schools, building positive expectations

for success, and reducing fear of failure. A visionary teacher education institution or school knows what its future looks like; therefore, it can better recognize and seize opportunities that lead to it.

- *Visions are holistic.* Visions are holographic and they happen at multiple levels within the teacher education programme—personal, departmental, institutional, even community wide. Individuals see an image of themselves in the vision, what they would like to become, or how they would like to meet future challenges.

Stakeholders also need to be part of the visioning process because it is important that the vision statement represent an invitation to own the future together. A process that empowers many people through shared dialogue and teamwork (Senge, 1990) adds great value to strategic planning. The learning community can enlarge its circle of influence through this process (Covey, 1989).

The following are examples of good vision statements that were adopted as part of a 2001-2002 technology plan by the Government of Alberta. Although focused on K-12 education, they demonstrate the elements of a powerful vision for technology in learning:

...the performance of all students and staff is improved through the appropriate use of technology. Planning at the school, department, and district levels will ensure that access to technology is equitable and cost-effective. Parents and members of the community will understand and be supportive of the ways in which technology is used in schools to enhance learning and teaching.

Through the effective and efficient use of technologies as empowering communication and productivity tools, the district, in co-operation with its greater community, will enhance the education system for students, teachers, other staff, parents and community members, using appropriate information, applications, systems and communications technologies that will improve and maximize learning, productivity and performance:

...develop lifelong learners, who are confident in using technology to solve problems, develop critical thinking skills, communicate ideas, and work collaboratively on multidisciplinary projects.

...technology is causing the process of schooling to undergo significant changes. Included in this change are the methods by which students learn. Technology should be viewed as an appropriate part of every curriculum at every level of instruction and learning, not as a separate curriculum for learners. Administratively, the technology has the capacity to transfer data and information more efficiently, and to enhance communication processes. Accordingly, careful planning for the management of technology and technology related support and service is a division priority. (Government of Alberta, 1999)

The following recommendations by John Kotter (1996) may help the planning team to develop the vision statement:

- *First draft:* The process often starts with an initial statement from a single individual, reflecting his or her dreams.
- *Role of the guiding coalition:* The first draft is always modelled over time by the guiding coalition or an even larger group of people (such as an advisory group).
- *Importance of teamwork:* The group process never works well without a minimum of effective teamwork.
- *Role of the head and the heart:* Both analytical thinking and a lot of dreaming are essential throughout the activity.
- *Messiness of the process:* Vision creation is usually a process of two steps forward and one back, of movement to the left and then to the right.
- *End product:* The process results in a direction for the future that is desirable, feasible, focused, flexible, and is conveyable in five minutes or less.

Create the Mission Statement

The mission statement is a clear, concise description of the overall purpose of the organization's technology plan. The mission statement is more specific than the vision statement and should communicate clearly what the technology plan aims to achieve with technology. It describes what the institution will do to achieve the vision, why achieving the vision is important, and who the intended beneficiaries of the vision are. As with the vision statement, it is important to obtain support for the mission statement from the stakeholders in the teacher education

institution and community. Once the vision and mission statements have been developed, they should be presented to the chief administrators or policy board for approval before developing the other components of the plan.

Develop the Goals and Objectives

Goals are broad, comprehensive statements that identify the intended outcomes of the technology plan. They are statements of how the vision and mission statements will be achieved. The goals should specify the accomplishments needed if the vision is to become a reality, and should be clear, realistic, and attainable. The goals should include answers to the questions: who, what, how much, when, and according to which instrument?

The objectives are delineated from the goals and make clear how they will be achieved. They represent the specific steps-the specific activities-that must be accomplished to achieve each goal.

The objectives should have the following characteristics (a list that forms the acrostic SMART):

- S = Specific
- M = Measurable
- A = Attainable
- R = Realistic
- T = Timeline

Having developed the vision, the mission statement, and the goals and objectives, the planning effort is ready to move to the next stage of the process.

FORMULATION PHASE

The final phase in developing a technology plan is the formulation phase. In this phase the planning team develops the detailed plans for the teacher education institution to achieve the vision, mission, goals, and objectives of the plan. The team identifies specific projects, timelines for completing each component of the plan, and budgets. The stakeholders, including those responsible for carrying out the technology plan, must understand what is needed and what must be done to accomplish the vision. The plan must show how the technology will support

the curriculum and enhance meaningful, engaged learning for those in the teacher education programme. A well-written technology plan will answer clearly the *who*, *what*, *when*, *where*, *why*, and *how* questions related to achieving the vision and goals.

The many tasks involved in creating the technology plan will require a division of work among members of the planning team. The process may also require the support and participation of staff or consultants with needed expertise. As components of the plan are developed, it is helpful to continually ask the following questions:

- How will technology be used to improve learning and support a challenging curriculum through engaging instructional practices?
- What kinds of hardware, software, and infrastructures are necessary to support the educational goals of the teacher education programme?
- Will this technology be flexible, powerful, adaptable, and expandable?

As noted in the section on assessment tools earlier in this section, one suite of tools that may be helpful in developing components of the technology plan is Tech Builder. This resource provides a number of web-based instruments that can be used to acquire and analyze information needed to develop the plan. The free resource provides a database of the information collected and analyzed in the technology plan. Although designed for K-12 education systems, the tools can be used for teacher education technology planning. It includes a powerful search engine, analysis programs and display capabilities that enable a planning team to easily prepare reports, presentations, graphs, and charts.

Identify Issues

Many issues, concerns, and barriers must be identified and discussed as the technology plan is developed. The following are examples of the issues that may be considered:

Equity issues: A critical aspect of the plan is to ensure equity in the allocation and distribution of technology resources. Strategies and policies must be devised to assure that all pre-service teachers and teacher educators have equal opportunities to derive the full benefits of the technology. Some questions that should be considered include:

- How can technology resources be distributed among teacher education programmes and classrooms to ensure equitable access?
- How will budget and funding constraints affect equitable access and use?
- How will the plan address the needs of students with disabilities or limited proficiency in the national language?

Funding issues: What are the budgetary requirements for accomplishing the vision? What are realistic estimates of the funding available from internal and external funding sources?

Faculty development/technical support issues: What is the present level of technological skill and knowledge of teacher educators and to what extent is technology integrated into the curriculum? What resources are required to provide the needed professional development? What technical support will be required to sustain the planned programme?

Technology standard issues: What is the current state of the teacher education programme's technology infrastructure and installed base of hardware? What is the present level of connectivity in the classroom? What types of hardware and infrastructure are needed to achieve the goals and objectives of the plan? What decisions for platform standardization must be made (e.g., Windows, Macintosh, multi-platform)?

Teacher educator and pre-service teacher access to computers: Will teacher educators receive personal computers to accomplish their work? What configuration of computers will be used (e.g., computer labs, wireless technology-rich classrooms provisioned with laptop computers, classrooms with a single computer, projector and Internet access)?

Integrating new technologies with the installed base: What is the optimal way to use existing technology resources with new hardware and software? What is the planned life cycle of the hardware to be acquired? Has the total cost of ownership of the hardware been considered?

Facility issues: To what extent will the existing facilities accommodate or support the new generations of technology? Is the present infrastructure sufficient? Is the electrical system adequate and safe for use with the new hardware? If not, what is the cost to replace the wiring in the buildings? What type of security will be provided for the new hardware?

Develop Conclusions and Recommendations

Based on the analysis of needs, and after identifying the concerns, problems, and barriers, the planning team should prepare a set of conclusions and recommendations to guide the remainder of the planning process. The conclusions and recommendations should identify the most important needs and challenges confronting the integration of ICTs into the teacher education programme and recommend the projects and steps to be taken to achieve the vision.

Create a Technology and Learning Statement

This section of the plan will provide a more specific description of the intended use of technology in the teaching-learning process within the teacher education programme. It discusses the plan's model of student learning and the ways teacher educators and pre-service teachers will develop the desired knowledge and skills in integrating technology into instruction. This section may also discuss how technology may help transform the learning process and environment and change the roles of students from passive learners to active, engaged learners who take greater responsibility for their own learning (see Section I).

Identify Technology Standards and Requirements

One of the most important tasks in developing the technology plan is to determine the specific technology needed to achieve its vision and goals. The technology standards and requirements component of the plan will identify the hardware and connectivity/ infrastructure standards to support the planned learning environments. It will also identify general software requirements and provide examples of the software needed to address the learning goals and objectives. To develop the standards and requirements, the planning team must first understand the current resources available to the teacher education programme and then identify the additional requirements needed to meet the goals and objectives of the plan.

In some instances, teacher education institutions and schools identify their hardware and network software requirements before they choose the software to support the curriculum and teaching-learning process. It is often wise to choose the software first, based directly on the vision of the curriculum and what the students and teacher educators will be doing in the learning process. Will they be working collaboratively with others in the class and across the country? Will

computers be used primarily as cognitive tools with powerful programs for acquiring, analyzing, and creating knowledge? Will special tools be needed to support certain areas of the curriculum, e.g. hand-held devices and probe attachments for field science studies, social/economic simulation software, or multimedia presentation tools to develop instructional presentations? By choosing the software before committing to a specific hardware platform, possible incompatibilities in the use of the programs are reduced.

In developing the software standards and requirements, it is important to first review the software inventory information to identify what software is currently available and what will be needed to support the plan. Although the plan might not list all the software programs that are related to the objectives, it may give examples of the types of software programs congruent with the vision of the learning process and the school curriculum.

In developing the software requirements, the following types of software programs may be considered:

- Tool software: These are generic tools that may be used across content areas and include word processing, spreadsheets, databases, desktop publishing, multimedia, presentation, and web development.
- Curriculum-focused software: These include software programs with content or functions designed to address a component of a specific educational discipline or knowledge domain (e.g., learning specific mathematical or science concepts).

In identifying software needs, it is important to recognize that the quality of educational software varies greatly and thus software must be chosen carefully to best meet the programme's needs. In some contexts, there may be a lack of high quality, culturally responsive software. The plan may include provisions for the development of software to meet specific needs of the teacher preparation programme or the national educational system. Teacher educators working with pre-service and in-service teachers and technology and media experts may develop software to address critical needs.

The next step in the planning process is to identify the technology equipment and learning devices that will be needed to meet the instructional objectives of the teacher education programme. Standards and requirements for the hardware need to be identified. At one time, the term hardware referred only to computers; however, now it refers to an endless list of computers, peripherals,

presentation tools, and broadcasting and networking equipment. In developing the standards, it is important to consider the following questions:

- What type of technology is available?
- For what purposes is the existing technology being used?
- Who is using the technology?
- What are the important unmet needs?

The numbers and types of computers and other equipment needed will depend on the plan's vision of how technology may enhance learning. Will computers be in the classrooms, in computer labs, or both? What applications must the computers support (e.g., multimedia development, mathematical learning, writing and publishing, science experiments, Internet searches, web design, administrative functions)?

It is important to consider options for distributing computers that meet the goals of the plan and to understand the benefits and limitations of each option. The following are some points to be considered in making technology configuration decisions:

- *Computers labs* provide a convenient means for access to technology for a large number of users. They concentrate expensive resources in a single location that can be used by entire classes during instruction or as an open laboratory for individual student use at other times of the day. They reduce the costs of installing electricity, networking infrastructure, and servers to support use of the computers, and allow for more effective security. They also reduce connectivity costs to the Internet. The room selected may be larger than conventional classrooms to provide space for students to work collaboratively. Ideally, the facility is supervised and supported by one or two staff with technological and pedagogical expertise. The lab setting also may reduce software acquisition costs since all teacher educators and classes may share the same software tools.

The computer lab option also produces a number of constraints, such as competition among teacher education classes for access to the lab. Scheduling individual class use of the facility can be complex and may frustrate teacher educators and inhibit their use of the technology. It also makes just-in-time use of the technology by classes for learning projects and activities more difficult.

- *Placing computers in libraries* is an effective approach in situations where only a few computers may be acquired. This allows all students and teacher educators to have access to the computers, and to use staff available to provide assistance in accessing relevant information resources on the Internet.
- *Computers may be placed* in common rooms where instructors may use the technology for accessing relevant information and learning resources or to develop lesson plans.
- *Multimedia carts*, comprised of a computer, projector, and VCR allow instructors to demonstrate instructional uses of technology in their classrooms. If wireless access to the Internet is available in the building, the computer cart may be equipped with a wireless network card so that the instructor can access or demonstrate learning resources available on the Web.
- *Providing computers in individual classrooms* makes it possible for the technology to be accessed and used as part of the ongoing instructional process. However, it requires more than a few computers to be placed in the classroom, otherwise it will be difficult for the teacher educator to integrate the technology into the teaching-learning process. Placing computers in individual classrooms also provides a number of challenges such as the cost of providing electricity and connectivity to each room, renovation costs, space constraints, and costs for software and supplies to be used. It also poses challenges in providing security, maintenance and support services for the distributed computers.
- *A mobile computer lab* consists of a mobile cart containing a printer, wireless access point, and a classroom set of 20-25 laptop computers equipped with batteries and wireless network cards. The computers may be moved from classroom to classroom and shared by teacher educators. The mobile computer lab reduces the costs for installing electricity and connectivity in the classrooms. The laptop computers do not require special furniture and can be used by students at their desks. Printing can be done via the wireless network. The mobile lab also provides the benefit of lower software costs, similar to that provided by a computer lab. In addition, the mobile carts can be stored in a secure area when not in classroom use.

The mobile computer lab does pose some problematic issues that must be considered. The laptop computers are typically more costly than desktop computers, and the mobile computer lab provides the same potential for scheduling conflicts as noted for the computer labs. The

mobile lab cannot be moved between the floors of a building without elevators and is difficult to move between buildings unless there is a smooth walkway connecting the buildings. The use of the mobile lab requires a system for delivering the cart before each classroom use and retrieving the cart after the class, and instructors need to be trained in these procedures.

In developing the hardware requirements section of the plan, it is not necessary to specify the specific models of computers to be acquired. Technologies change rapidly, and a specific computer or other hardware item that may be state-of-the-art today might not be a few months from now. After the equipment needs are determined, the next step is to determine how the hardware will be acquired. If the plan calls for buying equipment, it is important to standardize purchasing as much as possible and set standards for accepting donations. If the institution standardizes on one or two platforms, it reduces costs for technical support, maintenance, and service of the equipment. It also provides the same environment in each classroom. Other considerations in planning for the acquisition of hardware include:

- Realistic appraisal of how much can be purchased. Know vendors' procedures and policies on warranties and service, and get these included in price quotes.
- Purchase hardware in the largest quantities possible to obtain the best pricing.
- Make sure the hardware purchased is upgradeable and will connect to a network. There are Internet sites for online purchasing from major manufacturers (e.g., Dell, Sony, Compaq, Apple, Fuji, Phillips, Cisco).
- Consider leasing. Its advantage is that obsolete equipment may be traded in for new models.
- Keep informed of new and innovative technologies.
- Do not spend all at once; spread purchases over an extended period. This keeps equipment from becoming obsolete all at the same time.
- Consider donations, but set a minimum standard and consider the issues of maintenance costs, decreased utility, and "one-of-a-kind" concerns.
- Electrical wiring and facility costs must be part of the planning. Many schools in old buildings fail to provide the electrical capacity to handle computer equipment, adequate ventilation and cooling systems, additional telephone lines, and security systems (SEIR*TEC, 2001)

CONNECTIVITY: PLAN THE NETWORK INFRASTRUCTURE

Although not visible, one of the most critical elements of the technology system is the infrastructure that supports the network and provides the connectivity and communication capabilities for each of the connected computers. Planning the network infrastructure is an essential element of the technology planning process and the plan should be designed to meet not only the current needs, but also have sufficient capacity to meet future requirements. The goal should be to establish information systems and infrastructure which maximize connections among teacher educators, pre-service and in-service teachers, and students, and which provide access to expertise and information resources from universities, museums, libraries, and databases around the world.

It is clear that the development of detailed requirements for the network infrastructure requires specific technical expertise. It is possible, however, to identify the general needs and requirements for the network infrastructure as part of the technology plan. If the teacher education programme is part of a university, it would be important to align the network plans with those of the institution. In some instances, local telecommunications companies may be willing to provide some assistance in defining the infrastructure requirements.

Plan Technology Professional Development

The most significant factor in enabling teacher educators to integrate technology into the instructional process is faculty development. Too often technology plans provide substantial funding for the acquisition of hardware and infrastructure but provide limited funding for the needed professional development and support. Failure to provide teacher educators and staff with adequate professional development opportunities may result in limited benefits from the investments in computers and related hardware. Successful programmes for training teacher educators to integrate technology are emerging after years of experimentation. Three essential factors related to creating a successful teacher educator professional development programme are:

- First, administrators must provide development programmes that serve teacher educators with very different skills, needs, and interests. A fully rounded training programme should include not only introductory classes for those who need to learn the basics, but more advanced classes as well. It should have in-session training seminars and online courses. It should have short, targeted programmes that tackle one subject in

a couple of hours (how to create a PowerPoint presentation, for example) as well as semester-long courses or workshops.

- Second, effective development programmes involve teacher educators at every stage of the process. Teacher educators must identify their training needs, help plan the curricula, act as mentors, and provide feedback. In addition, teacher educators must be committed to using their newly developed skills in the classroom as soon as possible, because the training lessons will fade over time.
- Third, the best programmes use technology to teach technology. This type of hands-on exposure greatly enhances the acquisition of necessary skills. Engage the teacher educators in projects during training classes and in follow-up activities at their institutions or schools in order to cement the lessons learned.

The technology plan should identify an effective staff development programme to support achievement of the plan's goals. There are different strategies and resources that may be used for professional development. The one that is least effective is the single large group workshop without follow-up or support. Better strategies for technology professional development include:

- *Creating model teacher education programmes* in the country to explore and pilot new practices and technologies that may be extended to other teacher education institutions. The model teacher education programme is used as a training site for other teacher educators in the region or country.
- *Developing a technology resource team* comprised of teacher educators who have successfully integrated technology into their instruction. These teacher educators are provided with additional training, and they then provide training and support to teacher educators in their programme or other programmes. The resource teachers may team-teach for brief periods to assist other teachers in integrating specific technologies into their instructional practices.
- *Using self-instructional professional development programmes and materials.* Many high-quality technology professional development materials are available on the Web. Materials are also available from a number of vendors.
- *Mentoring*, in which one teacher educator with higher levels of skill and knowledge mentors two or more teacher educators in specific applications of technology in the learning process. The constraining factor is

that many teacher educators have limited time for interaction and collaboration because of heavy teaching loads.

- *Telementoring*, in which teacher educators become their own best support system. The teacher education programme may establish online conference areas as part of the network system where faculty may seek help, advice, and support from other teacher educators.
- *Visiting classrooms*, particularly if the visiting teacher educator has sufficient opportunities to observe the instructional activities and to discuss with the teacher educator how the activities were planned and organized.

Although professional development is critical for teacher educators, it is also important to consider the training needs of other staff in the institution in planning the technology implementation.

Plan for Technical Support Services

The technology plan needs to identify the services needed to support the implementation of the plan. Providing the equipment, software, and training will launch the programme, but for it to be successful, it must provide for the ongoing and long-term support of technology systems. Failure to provide for support will lead to a gradual decline and eventual rejection of the new technologies that have been so carefully planned to improve learning.

Technical support is needed to maintain the network, servers, and computers in the computer laboratories, classrooms, and staff offices. In developing the technology support system, institutions will often hire a network administrator or technician because of their specialized skills; yet also expect this person to assist the teachers in the application of technology in instruction. This typically does not work well, because the technology specialist lacks the pedagogical knowledge needed to help teachers in technology integration. A more effective approach is to have on-site and on-demand professionals with expertise in technology and pedagogy to work with teacher educators, but finding professionals who have expertise in both areas is difficult. The technical support system may need differentiated staff to provide the technical and instructional expertise to support the implementation of the plan. Personnel is as important as hardware and software, and professionals with high levels of technology skill as well as those who understand how technology fits with instruction are necessary for the success of the technology plan.

Project Timelines and Budgets

After the vision, needs, goals, objectives and major projects of the technology plan have been developed and the foundation for successful implementation has been firmly established, it is important to identify the timelines for the initiation and completion of the specific projects and related tasks included in the plan.

It will not be possible to work on all tasks simultaneously. For example, the installation of network infrastructure may need to be done before the computers are installed. The plan will need to identify the sequence in which projects and tasks must be completed.

Timelines are usually presented in the form of a chart or table that lists the project or task along one side of the chart and the timelines for task completion on the top of the chart. Gantt charts are useful tools for identifying project tasks and timelines. They may be done on a sheet of graph paper or on a computer. Preparing a Gantt chart involves listing all of the major projects or activities in the plan down the left side of the page. Across the top of the page are listed the weeks or months available for completion of projects in the plan. The tasks are then plotted onto the chart by drawing a line for each task showing the start date and the end date. The Gantt chart need not identify all the tasks required, but it should at least identify the major projects or tasks that are critical to the success of the implementation. It should provide an estimated target date for initiating and completing each project or task.

Budget and costs: Ultimately, planning the implementation costs will be the most critical concern of the administration. In developing the plan, it is therefore important to carefully estimate all costs involved. If costs are overestimated, the plan may be rejected as too expensive. On the other hand, underestimation of costs can cause serious problems during implementation and may result in loss of support for the plan.

Bakia (2002), in a study of the costs of computers in classrooms in developing countries, found that initial hardware costs represent only a fraction of the total annual project costs. She notes the importance of considering the total cost of ownership (TCO) of the technology when estimating costs of ICT projects. TCO includes all of the costs involved in operating networks and computers, whether leased or owned. Traditionally used by businesses to help control costs and make strategic decisions, the concept of TCO in the education environment can help officials plan better budgets and make smarter choices when they deploy a network.

The budget should include all of the costs for implementation of the plan. These include:

- *Hardware costs*, including both initial acquisition costs and estimated replacement costs based on the estimated life cycle of the technology (e.g., many businesses replace computers every 2-3 years; most schools replace computers after 5-7 years.) Bakia (2002) found that equipment costs consumed 17%-49% of total project costs.
- *Software costs*, including estimated annual expenditures to acquire new software tools and to replace obsolete software. The costs vary depending on the number and configuration of computers to be acquired. The percentage of the budget for the acquisition and maintenance of software may range from 14%-26% of the project costs (Consortium for School Networking, 2001).
- *Connectivity and infrastructure costs*, including installation of network servers, cabling, routers, switches, wireless access points, and costs for Internet access via local telecommunications services or satellite. Connectivity costs will depend heavily on the type of connectivity made available to the teacher education institution. Telephone companies in many countries charge for Internet access and even for local calls. Where telecommunications are still operated by monopolies, the prices can be quite steep. Bakia notes that a dedicated line in Turkey is likely to cost \$80 per month, and in Ghana, schools are paying an average of \$86 per month in telephone dial-up charges. It is, therefore, important to consider these costs in developing the technology plan budget.
- *Maintenance and technical support costs*, including technical support personnel, special tools and equipment, and replacement parts. Once computers and networks are installed, technical staff are needed to maintain and support them. Users also require regular support. Bakia (2002) notes that in Chile, maintenance costs for schools were estimated at 10% of the equipment costs, while in Egypt, these costs were estimated at 4% of total costs.
- *Professional development costs*. Professional development is the most important element in achieving the technology plan goals. If teacher educators and other staff members do not understand how to use new technologies and incorporate them into the teaching-learning process, the teacher education institution's technological investment will not achieve its desired results. A substantial portion of the budget should

be allocated for faculty and staff professional development in the use of the technology. The U.S. Department of Education, for example, recommends that 30 percent of the total technology budget be allocated to staff development. The budget for professional development should include costs of training and support staff, professional development materials, participant stipends, etc.

- *Facility renovation costs*, to adequately house and support the technology resources acquired in the plan. This may include installing or upgrading electrical wiring or modification of the facilities to house computer labs. The costs will vary based on the age of the buildings, the capacity and condition of the current electrical systems, whether asbestos removal is necessary, and many other factors.
- *Supply costs*, including such items as toner cartridges for printers, paper, ZIP disks, and CD-Write disks.
- *Utility costs*. The computers and other technology resources and facilities will increase the cost of electricity, heating, and cooling. It is helpful to discuss the plans with the utility companies since they may have experience in estimating the impact of technology on increased utility costs in business and industry.

It is helpful to use a spreadsheet in preparing the budget to allow continual changes and refinements as cost estimates are developed. The budget should be clear and specific in regard to the amount and purpose of each budgeted item. It is also helpful to provide a rationale for each budget item following the budget page to explain its importance to the plan and the basis used for developing the cost estimate.

In developing the budget, identify the sources of funding for the different components of the plan. For example, the facilities, network, and hardware may be funded with the institution's special equipment accounts, while the personnel, software, professional development and technical support costs may be covered by the operational budget. There may also be components of the plan for which external funding may be sought. All of these issues need to be clarified in the budget section of the plan.

Evaluating the Implementation of the Plan

The evaluation section of the technology plan identifies how the intended outcomes of the plan will be assessed and how progress toward the plan's goals and objectives

will be evaluated. It describes the purpose and focus of the evaluation and the methods used for collecting, analyzing, and reporting the information. It is necessary to identify the key outcomes of the plan and to specify the indicators that will be used to monitor progress toward achieving each goal. The following are examples of questions that may help guide the evaluation:

- How will the evaluation determine whether the plan is meeting the teacher education programme's learning objectives?
- What is the impact of the technology plan on student learning performance?
- How will the evaluation assess the extent to which teacher educators are integrating technology into their teaching practices?
- How effective are the professional development and technical support systems in meeting teacher educator and staff needs?
- Who will be responsible for collecting ongoing data to monitor implementation progress and to self-correct any emergent problems?
- How will accountability for implementation be assessed?
- How will the type and level of use of the new technologies be assessed?
- How will the level of technology proficiency gained by students, teacher educators, and staff be assessed?
- What are the criteria and key indicators of successful accomplishment of the plan's vision?
- How has teaching with technology affected faculty workloads and methods?
- How has engaged learning with technology affected learner attitudes and motivations?

The evaluation plan should list the specific types of information to be gathered, describe the methods to be used in acquiring the data, and identify the source of the data. Information can be gathered from teacher educators, students, administrators, and staff. Other information sources may include course syllabi, academic documents, professional development materials, maintenance records, learner performance data, and other relevant sources. Various methods may be used to gather data, including faculty or student surveys, interviews, focus groups, case studies, tests, and student electronic portfolios. Many of the tools used in the assessment of the current status of technology in the teacher education programme may also be helpful in evaluating progress in the imple-

mentation of the plan. The evaluation should also include a schedule for the submission of periodic reports on progress in plan implementation. This information can be included in the Gantt chart described earlier in this section. Including these elements in the evaluation plan will help assure an effective means of monitoring and managing the progress of the plan implementation.

A helpful resource in developing the evaluation is *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms* (U.S. Department of Education, 2000). It provides a number of assessment tools and worksheets that may be helpful in designing the evaluation plan. Another useful tool for monitoring progress of technology integration into the teaching-learning process is the SEIR*TEC Technology Integration Progress Gauge (SEIR*TEC, 2001). It can help the planning team to reflect on activities to date by comparing them to effective practices in technology integration and to consider strategies for maximizing the impact of technology on teaching and learning.

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VII.

MANAGING INNOVATION AND CHANGE

Implementing the teacher education programme's technology infusion plan and managing change are highly complex tasks, possibly the most challenging to face any leadership. This section provides guidance for educational leaders who want to introduce ICTs into teacher education programmes.

The first part considers the nature of innovation and change. It is followed by a consideration of who the key stakeholders are in managing change in higher education institutions. The main part of the section examines some major models or perspectives on educational change. These models, derived from studies of educational change conducted mostly in the USA and Europe over a number of decades, provide practical guidance on many aspects of managing innovation and change. The section concludes with a focus on the role of the organization's leader in managing change, and the critical task of professional development of the academic staff who are ultimately responsible for implementing change in teacher education programmes.

THE NATURE OF INNOVATION AND CHANGE

Innovation and change are not new, of course. Good educational leaders are constantly innovating as they strive to improve teaching and learning to obtain the best educational outcomes for students. Nor is the study of innovation and change in educational contexts new, and consequently there is a rich store of studies to draw upon for guidance.

The most important concept understood about change is that change is a process. Because of the interlocking nature of teaching and learning, the intro-

duction of change in one part of an educational system has an effect on other parts, rather like throwing a stone into a pond and observing the expanding ripples. Hence, change is not a linear process but more likely a cyclical one.

Preceding sections in this document have described the impact of ICTs and the issues to address in integrating technology into teacher education. In the last decade, ICTs have begun to transform many facets of life in countries around the world-economic, social, and cultural-and their impact is now seen in many aspects of school activities. The term "re-engineering schools" has been coined to encompass the kinds of changes that the introduction of ICTs in schools leads to.

What evidence is there that ICTs have led to lasting educational change? In Europe, the Centre for Educational Research and Innovation (CERI) within the Organization for Economic Co-operation and Development (OECD) has engaged in a series of case studies in a number of countries. These case studies demonstrate that the introduction of ICTs in schools is acting as a lever for change. The evidence points to changed approaches by teachers, the introduction of different forms of assessment, increased student motivation, and better student learning outcomes. For more information, see OECD Databases (2001), an online searchable database of references to research publications on ICTs.

The subsequent parts focus on the introduction of ICTs in teacher education programmes that adopt the framework for ICTs in teacher education detailed in Section II. It is important to keep in mind that the use of ICTs in teacher education is likely to have the same far-reaching changes in teacher education faculties as the introduction of ICTs in schools, and that there are many stakeholders involved, including funding or accreditation agencies and participants such as teacher educators and student teachers.

Another lesson from the introduction of ICTs in schools is that countries are likely to progress at different rates. Largely, these stages of progress are mirrored in those organizations providing teacher education. Fluck (2000), for instance, in a paper available online, concludes from his cross-country study that there appear to be three stages through which countries progress as computers become more prevalent in education:

Phase 1: where students in school first use computers, and information technology becomes a curriculum choice.

Phase 2: where information and communication technologies are used transparently to enhance learning opportunities in all convenient curriculum subject areas.

Phase 3: where the universal curriculum clearly includes topics of study that would not exist without information and communication technologies, and schooling for most students no longer fits the conventional model. (Fluck, 2000, p. 2)

Similarly, countries will be at different stages in their use and experience of ICTs in teacher education.

KEY STAKEHOLDERS IN MANAGING CHANGE

Fullan's writings on educational change (2001), although focused primarily on schools, help to identify the principal stakeholders in managing change. With the introduction of ICTs in teacher education faculties of higher education institutions, the seven groups of stakeholders listed below are clearly distinguishable. They need to be involved in the formative evaluation and dissemination of initiatives for ICT teacher education.

The dean or professor who has responsibility for managing change in the faculty, department, school or college. Other leaders may also be stakeholders if their role has an influence on teacher education.

The teaching staff who are most closely involved in managing change in their individual teaching topics.

Senior administrators within the institution who have responsibility for attracting resources so that the necessary infrastructure may be established for planned changes.

Student teachers who have an interest in acquiring appropriate skills and knowledge to use ICTs when they graduate and enter the teaching force.

School teachers, ICT coordinators in schools, and principals, including those who lead professional development for their colleagues and those who collaborate with field experiences for teachers in training.

Government agencies that set policies regarding higher education, teacher professional development and the economy.

Business and industry, which have a strong interest in the quality of graduates from higher education institutions, and as a result may sometimes be prepared to provide some of the necessary infrastructure for training facilities.

Although all seven groups of stakeholders are important in the implementation of innovation and the management of change in higher education institutions, this section focuses primarily on the first two groups: middle level managers (usually deans of colleges of teacher education) who provide leadership for innovation and change in their faculty, and the lecturers or academic teaching staff of teacher education programmes who implement change. We might think of these two groups as the leaders and those who implement change. Systemic approaches to change need to encourage shared leadership at all levels: top down, bottom up, and in middle management. Excellent ICT teacher education will facilitate development of the organization into an organization in which all participants can learn from one another and support one another's learning.

EDUCATIONAL CHANGE MODELS

Where do leaders and those who implement change start in introducing ICTs in teacher education? Where do they seek guidance in managing innovation and change? Over several decades of research, a few classic educational change models have been developed that help to answer just such questions.

In this section, we focus on four leading educational change models.

- Diffusion of innovations (associated with Rogers, 1995).
- Conditions of change (associated with Ely, 1990).
- Change agent's guide (associated with Havelock and Zlotolow, 1995).
- Concerns-based adoption model (associated primarily with Hall and his associates, 1987).

Although the following discussion of these four educational change models might suggest a sequential, linear process, it is important to remember, in reading about these change models, that teacher education is part of an interlocking system, as stated above about the nature of innovation and change, and that different parts of the four models will often be conducted in parallel. For a more comprehensive survey of educational change models, *Surviving Change* (Ellsworth, 2000a) is recommended. A much briefer account is available online (Ellsworth, 2000b). Both these sources influenced the writing of this section.

Strategies for Adoption of Innovations

Educational leaders who have decided (or been encouraged by other stakeholders) to introduce ICTs in teacher education, naturally want the innovations to succeed. What characteristics or attributes of the innovations are helpful to know about? What strategies associated with these attributes could be utilized in the introduction of ICTs in teacher education to encourage their adoption by teacher educators? The educational change model, commonly termed diffusion of innovations, may best help here. Rogers (1995) has written most about diffusion of innovations.

Rogers identified five key attributes of innovations. Knowledge of these, together with intervention on the part of educational leaders, will assist in the rate at which the innovation (here the introduction of ICTs in teacher education) is adopted (by teacher educators). Rogers terms these five attributes *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability*. Table 7.1 lists these attributes together with the kinds of intervention strategies educational leaders in teacher education can adopt.

What is important about these attributes is that many reports have shown that awareness of them, along with appropriate intervention by educational leaders, dramatically improves the chances of the innovation's adoption. Ellsworth (2000a), for instance, concludes from his survey of educational change that between 49%-87% of the variance in the adoption rate of innovations is accounted for by these five attributes alone. This means that if educational leaders can effect the kinds of strategies listed in Table 7.1, there is a high probability that ICTs will be successfully diffused through an institution and adopted by teacher educators, with the possibility of achieving lasting change.

Necessary Conditions for Successful Change

What else is required to help make an innovation succeed, beyond consideration of the five attributes discussed above? Are there any necessary conditions that need to be in place to facilitate the adoption of an innovation such as the use of ICTs in teacher education? The educational change model developed by Ely (1990) helps answer questions like these.

In a cross-cultural study of the diffusion and implementation of educational technology, Ely identified eight conditions that influence a change such as the use of ICTs in teacher education.

Table 7.1 Attributes of Innovations and Helpful Leadership Strategies

Attributes of Innovations	Leadership Strategies
Relative advantage	Try to demonstrate that ICT-enhanced learning is more effective than traditional approaches to teaching and learning. It would be helpful here to be familiar with some of the research evidence on the nature of change noted in the first part of this chapter.
Compatibility	Try to demonstrate that ICTs are not at variance with current views, values and approaches. No technology is culturally neutral, and so it is important to address this attribute openly and honestly.
Complexity	Try to demonstrate that ICTs are relatively easy to implement in teaching. To do this implies that leaders have some knowledge of ICTs, or can call on assistance as needed.
Trialability	Give teacher educators the opportunity to try out ICTs in a way that is not threatening. Time is required here, and so again is technical assistance.
Observability	Give teacher educators the chance to see the use of ICTs in teaching. It would be useful to see leaders using ICTs or to see other teacher educators using ICTs.

Ely's first condition is *dissatisfaction* with the current way of doing things. For example, the difficulty experienced in some countries maintaining up-to-date learning resources might lead to feelings of *dissatisfaction*. Anderson and Askov (2001), in a case study available online, describe making online resources available on CD-ROM to help overcome the unavailability of current education textbooks and the expense of subscribing to English language education research journals at the Rajabhat Institutes of Thailand. Figure 7.1 displays a range of learning resources made available on CD-ROM to help overcome the shortage of locally based learning resources.

A second condition specified by Ely is *assistance for teacher educators to acquire knowledge and skills* to use ICTs. It is a sad comment on many previous educational technology innovations in many parts of the world, that professional development of those using ICTs is frequently overlooked and placed last, after purchase of equipment and software. Teacher educators will need comfortable personal access to ICTs, which fits into their professional habits of teaching and research. Case studies of this are provided in Section V.

Figure 7.1. Range of Learning Resources on CD-ROM for Teaching in Thailand



Ely's third condition is that the necessary *infrastructure* be available. So critical is this condition that Section III is devoted to the essential components required to support ICTs in teacher development. Quite clearly, for ICTs to be used in teacher education, necessary equipment (including both hardware and software), cabling, and telecommunication links must be in place in teaching spaces, open areas for students, and offices. The profile of ICTs in teacher education may need to be raised to gain these resources because competition from colleagues in other disciplines such as science, who may not appreciate the need for technology in the college of education.

A fourth necessary condition, according to Ely, is that teacher educators be given sufficient *time* to learn about ICTs and to integrate ICTs in the topics they teach. An online case study from Penn State University in the United States (Anderson and Askov, 2001) describes how teaching faculty were given release time so that they could develop, or rather redevelop, teaching and learning materials when their courses were placed on the Web. Teaching staff at universities and colleges cannot be expected to develop new teaching materials while coping with regular teaching commitments at the same time.

A fifth condition identified by Ely is a need for *incentives* for those introducing ICTs in teacher education. Recognizing innovators for their efforts may, on occasion, be sufficient, but for some teacher educators who perhaps are satisfied with their current teaching approach, further extrinsic motivation may be required, such as a raise in salary or technical and clerical support.

A sixth condition of Ely is that *participation* of teacher educators in the use of ICTs needs to be expected and encouragement needs to be given; and a seventh condition is that there needs to be *commitment* by all involved. Again, the case study from Penn State University provides a pointer. When the adult teacher education department made a commitment to put a degree program on the Web, it was a shared decision, and all teaching staff were expected to comply. There needs to be adequate support from the institution for technical assistance and the necessary upgrading of equipment and software.

The eighth and final condition that Ely identified is that *leadership* must be evident. Educational leaders need to inspire and encourage the teacher educators for whom they are responsible. Leaders also need to be enthusiastic users of ICTs themselves. So critical is leadership in managing change that the issue is again addressed under a heading below.

A Guide for Planning Change

C-R-E-A-T-E-R, an educational change model developed by Havelock and Zlotolow (1995), provides a practical guide for the institution (university or college) or educational leader (dean with responsibility for teacher education), who has decided to embark on the use of ICTs in teacher education. C-R-E-A-T-E-R helps determine what the key stages are in any planned change and what should be done at each stage. It may also inform change at a regional and national level.

Havelock and Zlotolow have produced the *Change Agent's Guide* as a kind of checklist for those planning change. Contained within the *Guide* is a description of seven key stages. The seven stages are not linear but interrelated and cyclical, forming what they term the C-R-E-A-T-E-R model. Table 7.2 depicts the seven-stage model. The first letter of each stage descriptor forms an acrostic, C-R-E-A-T-E-R. This model has been successful in focusing strategic change in teacher education in US universities (Thompson, Schmidt & Davis, 2002).

There are similarities between, for example, the first stage of C-R-E-A-T-E-R and Ely's first condition of dissatisfaction with current approaches to teaching and learning in teacher education. This kind of overlap emphasizes that the education change models presented in this chapter should not be followed in a strictly linear fashion.

Table 7.2 Seven Stages of the C-R-E-A-T-E-R Educational Change Model and Tasks Needed at Each Stage

Stage	Key Activities
0) <u>C</u> are	Identify and make explicit the reasons that motivate individual stakeholders to renew education and for what purpose.
1) <u>R</u> elate	Bring the key stakeholders together to share their Cares and appreciate the cares of others, determining a shared agenda for change. Note that this stage potentially results in action for educational renewal.
2) <u>E</u> xamine	Analyze the current situation, opportunities and challenges for educational renewal in relation to the shared agenda. Use prior experience, the literature, and ethnographic approaches to the gathering of new information to inform the process.
3) <u>A</u> cquire	Gather as much information and resources to support the experiments that will be 'Tried'. This should involve many aspects, such as hardware, software, telecommunications, personnel, books, accommodation, and furniture.
4) <u>T</u> ry	Trial the development of ICTs in one or more ways to evaluate what works both formatively to inform the trial itself, which will then be adapted, and as a summative report for all stakeholders.
5) <u>E</u> xtend	Bring stakeholders and others together to share successes and challenges learned so far. Use this opportunity to expand the number of stakeholders, possibly to raise awareness of the potential of ICTs for educational renewal. Note that this stage should also result in action for educational renewal and will raise new Cares as the process starts to move into a new cycle of educational renewal.
6) <u>R</u> enew	This is the core process of educational renewal, where lasting changes result within the organization. It is valuable to consider the formal systems that will benefit from change, such as assessment and quality assurance, formal committee structures and public strategies. The lasting changes are impacted most by the Relate and Share stages described above.

C-R-E-A-T-E-R is a highly practical guide for those leading the innovation to introduce ICTs in teacher education. In their publication, *The Change Agent's Guide*, Havelock and Zlotolow include checklists for decisions and steps that need to be taken to guide those seeking to implement change.

Keeping Track of Change

While C-R-E-A-T-E-R guides educational leaders through each stage in implementing change, the *Concerns-Based Adoption Model*, or CBAM, helps those who implement change keep track of where they are. CBAM is particularly useful in tracking the stages teacher educators go through in their use of ICTs, and their level of ICT use.

In particular CBAM provides a guide for what individual teachers may need as they move through the CBAM stages, starting with raising awareness of the potential of ICTs, and ending with a means to collaborate with colleagues within and beyond their local organization. The focus on the individual's viewpoint and each individual may move back to the first stage with a new facet of ICTs. For example, teachers who adopt and move to the most advanced stage in the use of word processing for their work, may need to drop back to the awareness stage to adopt new applications such as data handling tools and web-authoring.

Hall and his co-researchers (1987) developed CBAM primarily to help track two aspects of change. First, to track the concerns of individuals (in this case, teacher educators) in terms of what they feel about using ICTs in their teaching and, second, to track their level of ICT use. In other words, CBAM can be very useful for diagnosing two different aspects of an innovation in process. The first diagnostic instrument is called *Stages of Concern* (see Table 7.3) and the second is termed *Levels of Use* (see Table 7.4).

Table 7.3 Stages of Concern: Tracking Seven Concerns that An Adopter May Feel towards An Innovation such as the Use of ICTs in Teacher Education Programmes

Stages of Concern	Diagnostic Assessment
1) Awareness	Knows about ICTs but is not concerned about them.
2) Informational	Wants to know more about ICTs.
3) Personal	Wonders how ICTs will impact personally in terms of time demands and own abilities.
4) Management	Has concerns about the administrative and logistic challenges imposed by ICTs.
5) Consequence	Begins to consider how ICTs might impact students.
6) Collaboration	Considers how to collaborate with colleagues involved in ICTs.
7) Refocusing	Has ideas about how ICTs might be improved or better implemented.

Change Models in Perspective

The four educational change models presented in this section were put forward by separate groups of writers. As stated above, the change models are not intended to be applied in a linear fashion-starting with diffusion of innovations, and proceeding through conditions of change, change agent's guide, and the concerns-based adoption model. Together, the four change models complement each other quite well, rather like four different views of the same phenomenon. What this section does is summarize, all too briefly, some of what is involved in managing innovation and change. For more detail, the fuller descriptions of the models described in this section should be consulted. Perhaps what the four change models together do best is exemplify that managing change is a complex process.

Table 7.4 Levels of Use: Tracking Eight Levels in An Adopter's Progress in Using An Innovation such as the Use of ICTs in Teacher Education Programmes

Levels of Use	Diagnostic Assessment
0) Non-use	Not involved with ICTs.
1) Orientation	Begins to find out what ICTs are about.
2) Preparation	Gets ready to use ICTs.
3) Mechanical	Focuses on immediate, rote aspects of ICTs.
4) Routine	Uses ICTs in a basic way.
5) Refinement	Considers changes in use of ICTs to improve student-learning outcomes.
6) Integration	Works with colleagues to find ways in which ICTs can improve student-learning outcomes.
7) Renewal	Considers how the use of ICTs might be improved.

THE ROLE OF THE ORGANIZATION'S LEADER IN MANAGING CHANGE

One thing the research literature is quite clear about: the role of the organization's leader is the most important single factor in bringing about change. ICTs will not succeed without strong leadership and vision. In teacher education faculties or departments, this leadership and vision must come from the dean, but there must also be strong support from the teacher education faculty's university or college.

Michael Fullan is a key researcher in the field of educational leadership (2001). Even though his work is mainly at the school level, there are likely to be close parallels between the qualities required of school principals and the qualities required of faculty heads. Principal among these qualities is vision, a vision of what can be achieved with ICTs. Without this vision, lasting change in teacher education is almost impossible.

Important as the vision of the organizational leader is, it is insufficient by itself unless the teacher education faculty share the same vision. After all, it is they who will implement the use of ICTs in their teaching courses. To achieve a shared vision across a group of people requires dialogue and discussion to build

consensus. One strategy is to take time out from regular departmental duties to work through the key issues-what Ely called dissatisfaction with the current way of doing things, and what Rogers termed relative advantage of ICTs over traditional teaching approaches. This discussion and sharing of the leader's vision with teaching staff cannot be rushed. For innovation to be successful and for lasting change to be achieved, a shared vision of ICTs is the initial, key step.

The organizational leader also needs to share leadership with other leaders among the staff. If there are planning and technology committees within the teacher education faculty, they will be influential in shaping attitudes towards ICTs. Good leaders will previously have shared their ideas with such faculty groups to ensure that all speak with a common voice. The shared vision may be an integral part of the Relate and Share opportunities managed strategically with the CREATER model.

Shared vision and shared leadership are key goals in the early stage of introducing ICTs in teacher education. If the innovation is to succeed in changing teachers' curriculum, modes of assessment, and approach to teaching, ICTs need to be integrated, embedded, or infused in the teaching of all topics in the teacher education programme. Facilitating educational change, then, becomes a key role for the organization's leader. Effective leaders lead by example and they provide support and encouragement for their teaching staff.

Further sources of information on the role of leaders in managing change and improvement are available on the Web from the North Central Regional Educational Laboratory (2001) in the United States.

LEADING AND MANAGING CHANGE

This section began with the statement that leading and managing change in the integration of ICTs into teacher education are highly complex tasks. There is an extensive base of research on managing change that is helpful in providing guidance on how to begin for those teacher education faculties wishing to embark on introducing ICTs into teacher education programmes. The educational change models described in this section should prove useful in suggesting strategies, in determining what conditions are necessary for successful change, in guiding such change, and in monitoring the change process. All of these change elements are essential in the successful planning and implementing of ICTs in teacher education. It is important to remember, however, that the two most important ingredients in the whole process of change are *leadership* and *professional development*.

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VIII.

ICT-SUPPORTED TEACHER EDUCATION: IMAGES AND SCENARIOS

INTRODUCTION

A *shared vision* is indispensable in any planning activity. Given the global context of teacher education and recent advances in its theoretical foundation, standards, and guidelines, and in resources for developing plans for the integration of ICTs, it is now feasible to conceptualize a realistic vision for ICT-supported teacher education. It is helpful to look at an example of how the concepts and strategies provided in the planning guide may be used to infuse ICTs in teacher education in ways consistent with a country's context and culture. The following images and design scenarios, developed by a team of world-renowned experts in ICT-supported teacher education and practising teachers in Moscow, show how the framework for ICTs in teacher education may be translated into ideas for teaching and learning activities and are based on long, practical experience in working with teachers in Russia and countries in Eastern and Central Europe and Latin America. The purposes of this section are:

- to present a vision of an achievable reality; a living embodiment of theoretical assumptions and methodological assertions, and
- to provide the readers with some generally applicable and useful working principles for achieving this vision.

The Principles of Teacher Development Using ICTs

The integration of ICTs into the very idea of teaching and learning might be termed the 'informatization' of education. Informatization represents the necessary component, condition, and catalyst for the modernization of education, which will permit the move from the reproductive model of teaching and learning to an independent model that promotes initiation and creativity with information. This new model of education reinforces the role of independent research. Learners are expected to collect, select, analyze, organize, and present knowledge. Teachers are expected to promote collective work and to facilitate individual and group activities. The implementation of this new model builds the information and communication competencies of students, including the habits of mastering the means of information and communication technologies. The most important principle for the individual development of a teacher is active, project-based learning. Teaching must be carried out in such a way as to strongly reflect the general principles of education, such as the implementation of an informatization programme.

A Model of an Informatization Programme

It is hardly wise to present here a number of case studies, even highly successful, from a particular country to show what we mean by informatization—there is always the risk that selected cases would be too parochial. Rather, we need models that are quite specific on one hand and truly universal on the other. A number of classes and workshops, conducted by this team of experts in ICT-supported teacher education and practising teachers in Moscow, have been built around such models. These educational events are videotaped, transcribed, annotated, and analytically interpreted. Although an hour-long video shot in a real classroom may be both impressive and enriching in making the audience acquainted with local colour and the pedagogical specifics of a particular schooling practice, it may not provide them with broadly applicable principles. It thus may be more helpful to try to select the most crucial features from the collection of amassed details concentrating on structural patterns and functional dependencies. The readers are thus offered these essential characteristics and traits distilled and refined, and presented as a generic scenario.

The organizers of this project conceive the workshops or training sessions on the basis of what is actually known and practiced today, having built a dynamic framework for teaching and learning activities with proper actors, tools, materials, operations, and procedures. In this way it is possible to describe and

demonstrate vividly the essential elements, connections, processes, and mechanisms of ICT-based teacher education without being constrained by the peculiarities of local settings. The resulting scenarios are thus not documentary videos of actual events, but rather animated cartoons of what is advisable to take into account as a starting point toward further development. Each scenario includes a commonly accepted maxim or generic statement; an interpretation, explanatory description, and visual enactment; and implications. Providing specific interpretations of a general notion is a powerful, simple, and easily understood method of explanation that helps the audience to become aware of what they may achieve on their own. The scenarios are compiled from the experts' actual experience of more than fifteen years educating thousands of teachers in the former republics of the Soviet Union, in Central Europe and Latin America. In the narrative that follows, the process of teacher preparation, involving the use of documentary videos, as a promising model for teacher education, is described.

Major Participants in the Process

The major participants in the process of teacher development and thus major "players" in this model are:

- a) *Educational designers*: The role of an educational designer is to provide heuristic and conceptual support at those moments when an urgent and ill-defined problem presents itself to the teacher working alone.
- b) *Professors*: The classic role of the professor has been significantly transformed. Rather than being the source of all information, at best a professor will only be able to trace the ever-accelerating ICT-related changes in education in general. It is unrealistic to suppose that after a year or two professors will become adroit users of even the basic ICT applications in teaching their subject matter. This means that for the systematic assimilation of such technologies, professors must get help from technologists (see below).

Professors may be subdivided into at least three categories:

- Those who, having generally positive attitudes towards ICT-usage, encourage their students to acquire computer literacy, thus raising the standard of teaching and learning in the whole system
- Those who are neutral towards the use of ICTs in education
- Those with explicitly negative attitudes towards all new technologies.

- c) *Technologists*: Technologists may be defined as follows:
- ICT-experienced colleagues in teacher education
 - Professors of ICTs, highly competent, but rather less orientated to technology-related pedagogical perspectives
 - Technical ICT experts and computer 'gurus', having no educational background
 - Practising teachers competent in ICTs
 - Student teachers competent in ICTs
 - Schoolchildren competent in ICTs.

The technologist's role may include:

- Participating as a co-teacher in classes given by a professor
 - Conducting classes in conjunction with the content and schedule of the professor's course; i.e., by choosing the same subject areas and cognitive tasks as a field for application of particular ICT tools, aimed at solving specified teaching and learning problems
 - Teaching modules generally synchronized with, but not necessarily developed for, a professor's course
 - Supporting students' independent work, in a task-oriented way within the framework of the course
 - Facilitating interdisciplinary projects with the participation of several professors.
- d) *Technical assistants* (programmers and electronics technicians).
- e) *Student Teachers* (both professionals enrolled for certification and undergraduates).
- f) *Pupils* in schools in partnership with teacher education programmes.

THE PROCESS

Diverse Forms of Professional Development

A key element of our process is to provide the future educator with diverse forms of professional development. One important form of professional development consists of *visits* to educational institutions that have varied experience using

information technologies in teaching and learning. These visits may provide a range of interaction opportunities, from after-school discussions and apprenticeships to collaborative work or interaction with the whole educational ICT community. *Project Seminars* also provide a number of practical teaching skills, along with the theoretical knowledge on which they are based, in a context in which the need for such skills is always conditioned by the learning context and tasks. The course also includes summarizing *lectures* and *discussions*, where concepts, strategies, theoretical frame-works, and ideas put forward by the professor are reviewed and criticized by students, and sufficient time is devoted to giving detailed answers to students' questions. All stages are recorded in detail. In this way, these lectures also become part of the project work. The results and outcomes of the project-based activities of each learning group include reflective analysis of the process of group work, and are used by students in further school-work and by the professors in their work with future student teachers.

Diverse Forms of Learning Environments

In addition to experiences within a physical environment, the programme also makes use of a virtual, truly boundless teaching and learning environment-the Internet. Networked interaction between students, students and professors, students and other Internet users locally, nationally, and globally begins during training and is continued after the teacher preparation course has ended. The main course site references the initiatives, results, and resources developed by activities of the previous student teachers in their educational systems, and provides information on the activities of their pupils.

Two Streams of Learning, Enhancing Each Other

Educational ICTs work most efficiently when used in solving problems that are important and interesting for students both in their private lives, and especially, in their learning activities. Thus we come to two 'streams' of assimilation and mastery of ICTs in educating teachers.

The first stream flows throughout general teaching courses, which encompass pedagogy, content, methods, and organization of the teaching and learning process. The second stream flows through separate modules in which ICT skills are mastered in a planned consecutive order and applied by the students to solve educationally relevant and personally interesting problems. In this way the modular structure of ICTs emerges quite naturally. Every module, organized around a

separate project, introduces students to a particular area of ICTs while developing their working capacities in other areas. Each stream is subdivided into an introductory activity and systematic teaching. These two elements, however, constantly overlap and enhance each other. This provides a basic model for a teaching and learning activity in school, although it may be modified and customized widely according to circumstances.

The components of an introductory course, described below, are designed to provide the teacher with a range of ideas in relation to educational ICTs. The course also describes a number of basic skills that enable one to grasp the variety of information objects, to search for particular items within a large amount of data, and to connect them together and build coherent entities. It also provides—right from the start—an introduction to the systematic acquisition of technical and "hands-on" skills needed to manage fluently particular ICT hardware and software tools and systems. Preferably, this is done within a project-based model. The most suitable might be projects closely related to the issues of one's profession, family life, personal interests, etc. (See Table 8.1 for specific examples.) The aim of such projects is not only to help teachers learn specific pedagogical aspects of ICTs, but also to motivate them to use ICTs as tools to produce something useful and tangible that will enhance their teaching practices.

In this process, the central figure is the student teacher, who is taught by the professor within the framework of the curriculum developed by the designer. The hope is that the activities used with the student teachers will eventually be used with their pupils.

FOUNDATIONS: CONCEPTUALIZING TEACHING AND LEARNING

The Teacher as Learner

As preparation for understanding, it is essential to reconceptualize the roles of professor, teacher, and student in the teaching-learning process. In previous generations, and at least until the twentieth century, training teachers was a comprehensive task. Learners were organized in a pyramid, with each successive level representing a "better" learner. At the highest levels of the pyramid were the "best" learners, those who came through school with the best marks and could teach the others the content they had learned. They in turn were taught by professors who continued learning after school in order to learn more than the graduates. Today, rather than a pyramid, the model more closely resembles a circle.

Professors are not the "elite;" in fact, in the face of rapidly changing content, they often cannot stay current.

Today's school tries to establish a real-world environment and make possible an approach in which knowledge does not pass from educational designers and text authors to professors, from professors to teachers, and from teachers to pupils. Rather it comes from all directions, and the roles of student, teacher and professor are interchangeable. In a successful ICT project all are co-learners, and students may very well support teachers, showing them how to use ICTs in their work.

In any case, all participants should learn and practice educational design. We can create a learning school in which enthusiastic teachers, children, and teacher trainers (including designers) explore, design, discover, and invent together, and learn experientially along the way.

The Student as Both Child and Adult

The best path to learn how to use ICTs in teaching is to live, feel, think, and behave as if one were not only an adult teacher but also a pre-adolescent pupil. The child in us enjoys playful immersion in a flow of exciting events that can be eagerly explored. The adult professional is able to exploit previously accumulated wisdom, capacities for logical reasoning, and formal analysis to critically reflect on the very process of learning. To be able to assume both roles is quite an asset for an aspiring teacher.

There are several diverse, often antagonistic philosophies, theories, and methods of education accepted and practiced in today's schooling. Under particular circumstances each of these approaches may be appropriate, and we should not exclude any of them perfunctorily. After all, good teachers always make their own customized toolbox, an individually charted map, or a highly personal guidebook compiled from many sources and experiences. Teachers may use ICTs in a variety of ways to support a traditional 'teacher-centred' way of teaching, such as drill and practice for memorizing facts and figures, or as automated tutorials to supplement teacher-controlled activities for particular pupils. Others may use ICTs to support a more pupil-centred approach, in which children conduct their own scientific inquiries or projects, often in collaborative groups, while the teacher assumes the role of facilitator or coach.

We believe that a good place to start is to ask an aspiring teacher to assume the role of a pupil who has an adult teacher who always stays beside her or him and is devoted exclusively to this pupil. The characteristics of this role include:

- A Teacher-Who-Always-Stays-Beside pays full attention to this pupil only
- A Teacher-Who-Always-Stays-Beside never leaves this one pupil for any other pupils in the classroom
- A Teacher-Who-Always-Stays-Beside learns the same new things (knowledge/skills) that the pupil learns
- A Teacher-Who-Stays-Beside is ready not only to help the pupil when s/he needs it, but to learn from the pupil as well.

Student teachers should investigate both roles. With this dual experience, they receive insight into how wonderful it would be to maintain similar relationships and exercise similar capacities in actual classroom practice.

We believe that modern ICTs work well in such a model. They promise the unprecedented advantage of achieving more in less time and providing a more engaging and responsive learning environment with fewer negative physical and psychological factors.

New Ways to Observe Learning

Behaviour, thinking, and content make up learning and teaching, at least as far as organized schooling is concerned. Through design in the 'authentic' reality of classroom practice these become accessible in two different ways. Behaviour is accessible through direct observation and recording (audio-video, etc). Thinking-previously accessible only through rather vague reconstructions based on speculation, reflective introspection, and mechanistic 'experimental psychology'-is currently accessible through the use of the computer. For example, new vistas and practical possibilities of observing objectively some important structural features and functional characteristics of the learner's thinking are revealed when the computer is used as a 'thinking tool' in various kinds of design, construction, cognitive-modelling, and problem-solving educational activities. The digital portfolio may provide a record of educational events and activities of a student teacher. The contents may include classification, annotation, indexing, connections with digital materials used in learning, and the work

of other student teachers. This portfolio may be used by the learner as well as by professors and future employers.

INTRODUCTORY COURSE

Assumptions

In most situations, we may assume that:

- The faculty of a teacher training institution, or other group working on a teacher education programme, have different levels of competence in ICTs.
- There are members of the group who understand the value of ICTs in education and have the educational background and experience to be ready to lead a work experience element. This work experience element we call the Introductory Course.

At the end of the Introductory Course the teacher will:

- Understand the major models using ICTs in education
- Be able to see elements of ICTs applied in the learning process
- Be competent in the technical and educational aspects of basic technologies.

Following the Introductory Course, the aspiring teachers will learn more about the content and methods of their profession and subjects, led by other professors.

Content and Pedagogy

How should we model for student teachers best instructional practices so that they may learn in the best way possible? Obviously, we want them to know how to help pupils to learn faster and feel better when using ICTs. We may begin by providing these student teachers with direct experience of ICT-assisted learning while they assume the role of pupil.

What is the content? Generally speaking, anything that teachers consider necessary and want to teach their pupils is considered content. Often, when we say we want learners to "understand" content, we want students to acquire declarative knowledge, i.e., "knowing that" something is the case. In teaching

declarative knowledge one may use the traditional teacher-centred approach of lecturing or telling the students the information or concepts to be learned. The learning of declarative knowledge may be enhanced by the use of ICT tutorial or drill and practice programmes [teacher-controlled ICTs], gradually advancing in complexity. At this stage ICTs are not taught to or learned by the pupils. There is no need for them as long as the instruction remains entirely teacher-controlled.

Procedural knowledge, such as learning procedural rules may also be taught using ICTs in a totally teacher-controlled context. Noticeably better results, however, are achieved when control is given gradually to the pupil. In this case ICTs become subject matter to be taught and learned, if only partially and in subordinate status.

Overview

The Introductory Course starts with a brief excursion—a kind of introductory overview—across the main fields of our (faculty and student teachers) common interests and concerns. The students have an opportunity not only to observe schools at close proximity, but also to gain some actual experience in how ICTs can be used in different teaching-learning situations. The course starts by examining the simplest cases of learning practices, and then continues up the ladder of educational/technological complexity, novelty, and sophistication. Student teachers are asked to express their thoughts and opinions and reflect on what they have seen, and on their own experience. The emphasis is on the learning process and on reflective analysis of the learning process itself and the use of ICTs within it.

The following scenario provides an overview of the ways ICTs are integrated into the Introductory Course learning process.

Session one: The First Encounter

Student teachers have their first encounter with ICTs while experiencing the traditional lecture class approach. To illustrate this stage of our programme, we will describe a lecture in an elementary school literacy methods class.

This first encounter, the pseudo-classical lecture, is simply an exposition of the material. We cannot even call the material content yet because content in the

full sense will be defined through joint efforts of teacher and pupil; it will appear eventually as a product of their communication and interaction. In this first stage, the teacher talks and the pupil listens and is supposed to memorize-and understand and appropriate-the material. By appropriate, we mean assimilate, acquire, make it one's own intellectual possession, connect it more or less coherently to what is already known and assimilated, etc. Such appropriation may not automatically occur. It involves hard work by both the teacher and the pupil.

Exposition has three sub-categories:

- *Memorization.* The pupil is expected to memorize the information the teacher gives out.
- *Interpretation.* The pupil must decide whether these words and phrases, which this dreary teacher utters, denote or connote something in extra-linguistic reality; the pupil must try to connect and relate them to something already known.
- *Valuation or envaluation.* The pupil must assign value to this information on a pragmatic level. If it is, for example, a story with several persons or parties (or even '*elementa*'), then who are the "good guys", what is the proper and just order of things, which side am I inclined to take and with whom do I identify?

Interpretation and envaluation, of course, cannot occur unless pupils have dutifully completed the syntactic memorization of the material to be learned. It is not always easy for pupils to learn when they only hear an exposition. Pupils may try to increase understanding by such strategies as positioning themselves so that they see the teacher talking or sitting closer to watch the teacher's face and gestures. When the teacher's lecture is accompanied by visuals of main points addressed, it is also helpful to read silently the teacher's words and phrases on the large screen. The displayed words make clear that these are the most important points to be remembered. It goes without saying that written (typed) words are much easier to memorize than spoken ones. If pupils can already read, there is both an additional impetus to improve sight-reading and an ICT tool to assist it!

One might imagine this inner dialogue occurring for a student:

- "It's really fun to *hear* a word and to *see it written* at once!
- Now I know that when I see, for example, the word "WRITE," I must *pronounce* it RAIT, and when I see the word "ONCE" I pronounce it WANS.

- And, what is, perhaps, even more important: when I hear RAIT I immediately *see* "WRITE" inside my head.
- So I can learn spelling much faster!
- So many good things to do easier, faster, and better-AT ONCE!"

The meaning of this imaginary dialogue may be made clear by revisiting the concept of learning as experienced both as child and adult, and as pupil and teacher. In this dialogue, it is not only the child-pupil, but also the adult-teacher who have a voice in this inner conversation. The true selves of the pupil and teacher remain mutually incommunicado during classes, except for those rare moments when they actually encounter, communicate, and interact on the levels of their own true selves. The event of true teaching and learning only occurs at such rare moments. All the rest, both before and after, is either a preparation for, or a consummation of that event. If we are to facilitate true learning, we must create environments in which this inner meaning-making occurs.

To help student teachers to learn how ICTs can support a lesson of this kind, we ask the students to assume the role of a first grade learner. We then divide the student teachers into four groups and locate the groups in separate rooms. Each group is exposed to a pre-recorded three-minute lecture about the teaching and learning of reading and writing by first grade students. The lectures are presented by video on large screens. The versions differ in the types and amount of additional ICTs used to enhance the effect of the teacher's speaking.

- *Version Zero.* The student teachers only hear the lecturing professor.
- *Version One.* The student teachers hear and see the lecturing professor.
- *Version Two.* The student teachers hear and see the lecturing professor along with the typed key words and short phrases of the speech appearing concurrently on the board.
- *Version Three.* The student teachers hear and see the lecturing professor, the key words/phrases, and related pictorial images (photos, drawings, diagrams, excerpts from documentary and/or animated video, etc.) appearing concurrently on the adjacent screen.

In all versions the student teachers hear a professor telling them the same content in absolutely identical wording and intonation. We assume that the content is relevant for student teachers and within their zones of proximal development.

When the lecture is over, each student teacher is asked to repeat the lesson. It must be done twice: first alone, just for the video and soundtrack recording; then in the presence of a tutor who listens sympathetically, but remains silent and does not show any negative reaction. The retellings by each student teacher (both alone and in the tutor's presence) are transcribed verbatim and printed out. The transcription needs time, and the student teachers use this break for training in typing or other tasks used in operating digital equipment.

At the plenary session students are given a hardcopy of the original full text of the lecture and their retelling of it. The length of the retelling made in each group will be scored against the length of the original lecture, and the averages will be presented in numerical and graphic form on the large screen. It is clearly shown that the length of retelling time increases with the addition of the image of the speaking lecturer, the visual presentation of the typed text, and, finally, the pictorial images. The student teachers are asked if they can explain this phenomenon, and we conduct a discussion, enabling everyone to gain the first insights into the great educational potential of ICTs. There is also a noticeable increase in the length of the retelling made in the presence of a sympathetic silent listener. This phenomenon is discussed in-depth at a later stage in the education of the students, when studying the use of ICTs for solving the problems of teacher/student interaction during classes, especially in distance education. This experience, at the very beginning of the teachers' training, provides an understanding of the limitations of "lecture-only" instruction and helps generate a positive attitude towards the potential of technology to improve learning and provides a model for educational research and design.

Session Two: Enacting Content

The core information source of session two is a "Panoramic Documentary" video comprised of a series of short vignettes of teaching-learning episodes in a number of primary school classrooms. Each vignette is an excerpt of an actual lesson by a number of teachers. The teachers shown in the samples are of different levels of professional qualification and years of experience. They adhere to different pedagogical systems and methods, and have different personal teaching styles. Above all, the sampled teachers use different teaching and learning tools and procedures (i.e. educational technologies)-from purely oral instruction, stripped of any auxiliary means of content delivery, to totally immersive and globally networked multi-sensory learning environments. Among the samples shown are excerpts of lessons in educational ICTs proper. The student teachers

can see the master-teacher on the screen demonstrating and explaining while the pupils learn 'hands-on' how to operate the computer with various peripherals.

In addition to each video sample, the designer provides the professor with the following in both digital form and hard-copy:

- A full transcription of the verbal delivery and exchange between teacher and pupils
- A story-board with sub-titles and an annotated map of topics, allowing the sample's overall composition and semantic structure to be understood at a glance
- A comprehensive analytical description, interpretive explanation, and evaluation of the educationally significant events that took place in the vignette.

The above materials and tools are made accessible to the pupils in due course.

Student teachers are divided into two simply named groups, 'orange' and 'violet' to minimize undesirable value-loaded associations. The groups occupy differently equipped and correspondingly colour-coded laboratories. Both laboratories contain similar large screens and high quality videoprojectors.

The groups in both 'orange' and 'violet' laboratories are shown the Panoramic Documentary only one time. Before the video is shown, the members of both groups are informed orally and in a typed text that they will be asked to submit individually written reports on the following questions:

- g) What, from your point of view, was the main theme of each lesson shown?
- h) What was the most pedagogically interesting feature of each lesson, irrespective of whether or not ICTs were used?
- i) What difference, if any, did the use of ICTs make compared to a regular lesson on the same theme without computer support? The latter is not necessarily shown in this session, though, presumably, well known to all members of both groups. In due course the samples of such computer-less lessons will be offered to the students as conceivable targets for possible 'informatization'.

- j) What, in your opinion, was weak, unsatisfactory, erroneous or wrong in the teachers' approaches, behaviours, and concrete actions in the samples? In what way might the lesson be corrected or improved?
- k) If you were asked to conduct similar lessons, would you (and could you- in the case of ICT usage) do it in the same manner? Describe how you would do it.

In both groups each member is given pen and paper, or optionally, a standard word-processor for making notes during the video demonstration and creating a report. Apart from this equipment, all other working conditions, *modi operandi* and procedures of the two groups differ sufficiently.

After watching the video the orange group has nothing to do but ponder and reflect, then compose and write or type their reports. In the violet group, members watch the large-screen video and are then given a multimedia computer with the same video easily operated through a simple 'point-and-click' interface. The students watch the video individually and can replay it again and again. They can view the video fully or partially and fast-forward, reverse, or jump to any specific moment for re-examination. It is possible to use variable speed, freeze-frame, instant access, picture and/or word search, zoom, etc., while listening to the audio over the headphones without disturbing others. They sit in their own small offices, a kind of a three-walled, open top 'cubicle'.

When the deadline is reached, we receive reports from the students of both groups, keep them sealed for a while, and announce an intermission.

During the intermission the professor pinpoints and selects from each report key phrases, which are called elements, and prints them out on cards, one phrase per card. After the intermission the professor distributes packs of 'element-cards' among the student teachers, and works with them on an individual basis. With the stacks of element cards, students are asked to spread them out on the table and sort them into piles with as many or as few cards as they want. Following this initial sort, the professor asks the student teachers:

- to label the sorted piles of elements and spread them across the desktop in some semantically and spatially organized manner-for example, to position them somehow in relation to each other along vertical and horizontal axes
- to think of what makes them a group and to show with pieces of coloured thread how many links of any kind each pile may have to others

- to organize the piles into meta-groups, called conceptual constructs
- to talk as they work, describing the reasons for their choices and decisions.

This activity of sorting, grouping, and making constructs and comments is videotaped and stored with previous reports in the student teacher's digital portfolio, without, for now, being shown to that student.

It is not surprising that the end-products of the first session-the written reports, the number of element cards and their grouping, as well as the complexity of conceptual constructs-differ drastically between the groups in many important aspects. The violet group's reports are typically significantly longer, more detailed, and cover a wider range of relevant topics. Their constructs have more components (piles of cards) and links which tie them semantically, i.e. more interconnectedness. As they describe the meaning that they make of the video recorded samples, the violet group identifies more causal relationships between teacher actions and pupil action than does the orange group. In other words, the violet group's understanding of the classroom scenes is deeper and more articulated.

The orange group generally feels upset with their poor results, and the professor may use this opportunity to ask if they have any thoughts about the reasons for the poor outcome. If they answer that it had happened "just because we didn't have the opportunity to replay the video many times," the professor will ask each one for a more detailed written explanation. Analysis and evaluation of these explanations is postponed until later, and the orange group is invited to try their luck by taking the next step.

The orange group is then given the same opportunity to work individually with computerized video as the violet group did. Chances are that the orange group's results will be not only on a par with those of the violet group, but probably at an even higher level of detail and complexity. This is because in the second run of descriptive reconstruction of the samples, the orange group has an advantage over the violet group. This time orange group approaches the sample video with the written reports at hand, which they may first use as an initial framework, and can then elaborate and improve upon with the help of ICTs. Moreover, while writing an explanation of their failure, they have previously reflected on what can be done using computerized video equipment.

The violet group may then feel somewhat disgruntled, saying they could have done no worse had they been told to use their 'organic' memory first, and

only then turn to the computerized one. This is true, and so now we invite each member of both groups to write individually a full story of what happened during this experience. These full stories are processed for selecting the key phrases to be used by the student teachers in the second run of sorting element cards and making conceptual constructs on the desktops. The chances are that this time there will be no serious disparity in the average results scored between the two groups, and the results themselves (a degree of complexity calculated from a volume of elements and links within conceptual constructs) will be noticeably higher. No group feels offended by getting lower marks, although individual results within the group can be very significant, and we shall soon pay them special attention by analyzing the reasons and sketching out some promising solutions.

The most important results from this activity are:

- The student teachers' faculties of *understanding*, *making sense of* and *finding meaning about* educational ICT usage were obviously rapidly expanding its scope in the process.
- The growth of this capacity was accelerated and expanded due mainly to the employment of the very same ICTs as exceptionally powerful teaching and learning tools and environments. It was clearly evident that student teachers without access to computerized video initially lagged behind the other group but made a real breakthrough after having the technology at their disposal.

Session Three: Learning from Masters

Teaching, fully understood, includes instruction, tutelage, mentorship, training, fostering, supporting, scaffolding, facilitating, etc. It is more than just science, theory and methodology, which can be acquired through traditional academic means; it is an art and craft, which is only likely to be appropriated through cognitive apprenticeship. In other words, the aspiring student *must* observe and imitate the work of a master. It is worth noting that the word *mastery* has the double connotation of power to control one's surroundings and the wisdom to use this power appropriately. Mastery may be thought of as biological/evolutionary in its origins, but the use of crude tools and the invention of language changed the vehicle of mastery from the process of natural selection to cultural/historical and technological development.

In ancient times mastery was inseparable from the sacred proto-technologies (especially healing and metalworking) of shamanism and liturgical ceremonies, practised by truly wise men and women-masters in spiritual traditions. Unfortunately, as technological capabilities increased, this wisdom aspect of mastery became less important and was finally forced out by purely economic or military considerations. Contemporary master teachers are called on to restore the dual meaning of mastery in its completeness. To achieve mastery, one must have significant procedural knowledge. The master demonstrates skill in the craft, and the apprentice, observing, begins to learn the craft, skill by skill. The apprentice gradually gains competency, and develops clusters of skills for performing definite tasks and knowledge of procedures.

We postulate that the process of learning per se must be considered as a craft, or as an indispensable component, of gaining mastery. Since, in our modern society, the skills of reading and writing are indispensable tools of learning, these skills must be taught if a student is to achieve mastery of the learning process. The writing-reading craft cannot be learned naturally as can speaking the mother tongue; it needs to be taught systematically in a specially organized environment. It can be taught and learned quite quickly and pleasurably in a family or small private school setting; it takes ten times longer or more in a classroom of 30 pupils. In a typical classroom an average teacher can truly communicate and interact with just one pupil at a time. If 30 pupils need an equal share of the teacher's attention, each would have less than two minutes of learning interaction and communication with the teacher in a 45-minute period. Our task is to create a more effective learning environment through ICTs in which the craft of teaching writing/reading may be mastered.

As previously mentioned, the best way to learn is to observe a master. The trouble is that genuine master teachers are scarce and accessible only to a chosen few. Each can mentor perhaps half a dozen apprentices, and, until very recently, the time-span needed for an aspiring apprentice to become equally knowledgeable and skilful in teaching inevitably stretched to many years, if not decades. In addition, the ways in which an apprentice could observe the master were limited. Observation was not possible at any moment, from any angle, or at a close distance. If an important move was missed, the apprentice was unable, more often than not, to ask the master to repeat, even less to explain, this move. Consequently, the apprentice had to wait for days, weeks, months, perhaps even years until the master perchance repeated that move in a similar way. During this long break it was beyond the apprentice's ability to remember the detailed mental picture of all the relevant accompanying circumstances-a

condition absolutely necessary to form a coherent, meaningful pattern of quickly moving ongoing events.

Such are the obvious limitations, restrictions, and deficiencies of traditional pre-industrial apprenticeships. For the last two centuries, apprenticeship has been thought obsolete because it was totally incompatible with the machine, the epitome of industrialization. The post-industrial era prompts us to revise this view profoundly.

ICTs offer new options for the apprenticeship model. Long sequences of events can be recorded and kept for posterity. It is easy to replay these sequences at full length or in part, selected for the closest and most meticulous scrutiny. A student-apprentice can watch a master working from many points of view, around the clock, seven days a week if desired. It becomes possible to approach exemplar activities with learning strategies unthinkable in the past. The results promise to infinitely exceed, in relation to the time required, those achieved earlier through the natural capacities of the naked eye.

With ICTs, we can capture through video the best teaching practices of master teachers and share them with novice teachers. We can record electronically almost everything related to their joint teaching/learning activities. After collecting a sufficient amount of such material we can select, edit, and deliver these materials via multimedia CD-ROMs, DVDs, and WWW to any number of novice teachers applying for apprenticeship. Every one of them would undoubtedly gain much first-rate information and knowledge of how each master teacher uses ICTs in education. In a certain sense, the novice would enjoy an even more privileged position than a genuine apprentice due to the technical ability to watch any particular event over and over again, in "real", "compressed", "expanded", or even "reversed" time; shot from various angles, and optically magnified to reveal minute details.

The fact is, however, that our novice-applicant would gain no experience of being accepted and treated as the master's apprentice. Watching this multimedia excursion, the novice would inevitably remain a passive spectator of, rather than an active participant in, the ongoing teaching and learning events. We should consider some ideas to provide vital interaction, either actually or in computer-generated virtual reality.

Summary of the Introductory Course

During the Introductory Course, the student teachers are shown a number of recorded scenes in which schoolteachers and schoolchildren use ICTs in various ways. They are asked to:

- l) Describe, interpret, and explain what they have heard and seen
- m) Make corresponding conceptual constructs
- n) Compose a summing-up essay with the help of the word-processor and the graphic editor.

After discussing the outcomes with classmates and professors, the student teachers are given a software package of the scenes they have watched, sufficient hardware with software tool-box, and a final task: to make a multimedia presentation (text, sound, diagrams, photos, video, and simple animation) of their essays' content.

At this point, the student teachers have enough elementary ICT knowledge and skills to work at the level of first-graders. The difference in their task from that of the first-graders is that the focus of their presentation must be an analytic/synthetic survey of the ICT-assisted teacher/pupil communication/interaction, however technically simplistic and naive. Each student teacher's action-adding, changing, or deleting an element-is saved automatically and filed separately as a numbered draft with an indication of which alphanumeric, graphic, or video sample from the sample-pool has been used and stored in the student teacher's portfolio.

The multimedia presentation given at the end of the introductory term serves as a point of departure and reference for further development of the student teacher. The latter part of the portfolio includes recordings of the student teacher's performance in the role of a teacher giving classes at the affiliated experimental school, with an indication which samples were chosen and used for imitation and modelling. These will be used for evaluation of the student teacher's progress.

Some of the professors will use ICTs extensively in their work and may be ready to provide a comprehensive array of technology-based learning resources to students. Some will ask a technology specialist to provide a few hours' technical training and will give students independent work in the course. A third option is co-operative work by the professor/technical expert

and the student teacher. The least desirable option is that students will use technology only with the professor's passive appreciation and support.

Basic Tasks and Objectives

During the Introductory Course, the students assimilate:

- concrete models of ICT-supported activities and some basic technical skills, and
- elements of the design of ICT-supported educational activities.

This assimilation helps students to develop their conceptual understanding of:

- the goals of contemporary education and the role of ICTs in achieving them, and
- the role of ICTs in the contemporary world.

A reflective analysis of this activity and situation is given in Table 8.5.

Thus, the teacher training programme includes:

- design activities, aimed at solving problems, which are interesting and personally relevant for the teachers, but belong to the types of problems faced by schoolchildren, and
- design of teachers' own pedagogical activity, which includes, of necessity, participation in creating an educational information environment for their institutions.

The entire course comprises an integrated and complex 'Big Project', consisting of two articulated parts entitled *Here I Am* and *Here We Are*. The main project is subdivided into smaller projects, of both individual and group types. Project assignments that may bring concrete and visible results upon completion offer important motivational factors which essentially increase the efficiency of the training process and the quality of its results.

Table 8.1 gives a detailed structure of model project activities selected on the basis of students' interests and time required/available. Table 8.4 illustrates the time estimate for course activities.

Organization of the Project Activity

The immediate aims in carrying out each project are:

- The improvement of qualifications (reaching new levels of competence) for a student teacher
- Production by the student teacher of hypermedia work, deployed on the Internet, or presented as a printout
- Production by the student teacher of a live performance of the project supported by contemporary information technologies for personal communication.

Depending on the theme of the project, the degree of the students' stages of readiness to use various technical and intellectual resources, the students' skills and habits, and individual or collective orientation, the project may be organized in various ways. However, the basic stages are as follows:

Introduction to the project, outline of a problem situation, and goal setting. As a rule, the seminar leader conducts the goal setting activity, but sometimes a student or a group of students can do this independently. As stated previously, the goal of the project must be understandable and interesting to the participants (students in the course and, by extension, schoolchildren).

Acquisition of technical skills necessary for realization of the project. Initial training is done during a short lecture-seminar class in which new skills are demonstrated and examples of similar projects by other groups are shown. The students gain the skills while working on the project and consolidate it while doing other projects. During the training process, the group records the acquired technical skills in the project diary.

ICT training in the form of instructor-led seminars is illustrated in detail in Table 8.2.

Planning and organization (designing) of the work, creation of groups and distribution of duties. Learning such skills as planning individual and collective work, or time allocation for phases of the project, is an important part of the information and communicative competencies being formed. The plan of work is undertaken by the students and agreed upon with the leader; it must be recorded and included in the description of projects deployed on the Internet.

Fulfillment of the project. Plan specification, distribution of duties, recording the project development, correcting the plans, etc.

Presentation of the results of work. The results of work may be presented live before the audience, and/or published as an article in a hardcopy or on the Internet.

Reflection and analysis of the process and results of project development, together with demonstrating the possibilities of its implementation in the schools where the participants are working, and elsewhere. The basic task of post-project reflection lies in demonstrating and recording possible variants and conditions for implementation of the project in various concrete conditions, and estimation of its general pedagogical and subject-specific pedagogical value.

An analysis of educational information resources is given in Table 8.3.

Teaching and learning in educational institutions that make efficient use of ICTs is illustrated in Table 8.7.

A number of projects can involve both computerized and computerless technology in their implementation. For example, the hyper-structures are initially modelled with paper, glue, string, etc. The possibility of implementing a project without computers, especially without peripherals, is valuable because of the severe scarcity of equipment. Understanding the primary intellectual elements of skills over their technical-manipulative elements is an important outcome of training. Information and communication technologies are simply effective helpers in the formation of organic information-communicative competence, which is essentially created by well-organized activity.

Practical Application of the Model

During the courses the student teachers use various models of ICTs in teaching and learning activities. During their student teaching activities, they will further reflect on the theoretical and practical elements of ICTs. When these students become teachers, they will apply in the classroom what they have learned and use with their own students the activities they have experienced. These activities include the following:

Hypermedia Composition

Compositions of this kind function as teachers' homework before their exposition of the lesson material in a classroom. After being deployed on the local network and then on the Internet, compositions can be used by other teachers and students in their own teaching and learning activities.

Multimedia Presentation

Pupils' presentations provide the opportunity to develop the communicative dimension of information competence. Instrumental support of textual theses, quotations, visual images, and sounds help organize more succinctly the thoughts and speech delivery of all students, even those who would, in other circumstances, need extensive scaffolding by the instructor in order to succeed.

Project and Process Design

Central to our model is the creation by the student of teaching objects and/or processes. It is important to remember the diverse ways in which these can be realized. For example, a design for classroom decoration, such as colouring and wall-painting, arrangement of plants, set-up of an aquarium, etc., or a playground design can remain at the program-design stage on the computer screen, worked up as a model in cardboard or Lego-blocks, or given complete life-size implementation by the designers under the guidance of the art teacher or the teacher of materials technology. Any of these outcomes has a certain educational value, depending on the teaching objective. For other purposes, for example in assimilating new arithmetic content, simply designing the process and having it remain on the computer screen serves as a complete educational experience.

Demonstration of Technical Skills

In completing projects, students must demonstrate technical skills that may be applicable in a variety of professional environments. For example, today one of the most urgently needed skills is computer keyboarding. The achievement of typing speed which is higher than the speed of writing with a pen on paper typical of an average adult requires much less time and effort than is usually spent by children during the mastering of the basics of calligraphy. Hence, there exists the possibility to develop the child's communicative abilities not only after the

development of psycho-motor writing habits is complete, but also in parallel, and even ahead of the latter. As for calligraphy, it can be mastered as an element of artistic culture in a step-by-step manner, and in organic conjunction with other forms of written communication. The student teacher will learn keyboarding and other professionally useful ICT skills in the first months of the education programme.

A list of equipment needed for programme implementation (for a group of 16 students) is provided in Table 8.6.

Immersion into Foreign Language

As a part of their project assignments, the students are required to experiment with computer-based (Internet) translators. They may also experiment with computer-based immersion programmes. The well-known method of immersion is based on the theory that language is best mastered if the learner is surrounded by only native speakers. The best of modern computer environments for learning a foreign language simulate an immersion environment by such elements as placing the student in situations which are interesting to the student, providing linguistic commentaries, checking and testing the student's progress, and providing automated recognition of the learner's speech. As part of their project activities, students may be encouraged to make use of such products to learn and appreciate other languages in the global learning environment.

Assessment

As part of a project-based programme, student teachers can experience, and learn to use, computer-based testing. A computer can be downloaded with a great number and variety of exercises on arithmetic, grammar, completion tasks, etc. This makes it possible to assess in many ways, and to increase the efficiency of work of both teachers and students. When such testing is conducted in a computer lab, the teacher and students may receive the results immediately. Computer-based testing, however, has many limitations, and the teacher must understand the limitations. Including such instruction in the teacher education programme may be very beneficial.

Mitigation of Problems of Children with Disabilities

ICTs make it possible to compensate for even serious deficiencies of the sense organs and supporting-motor apparatus. In cases of deaf and hearing-impaired, as well as blind and sight-impaired children, ICTs are used to enhance the functioning of a weakened organ, or to substitute for an inoperative one. For children with disrupted kinetic functions, even as serious as cerebral paralysis, ICTs provide the possibility of communicating and interacting by means of text input and manipulation of screen objects. During the teacher-training course such situations can be simulated by artificial restrictions of movement, low lighting, etc. An important emotional-motivational factor is offered by visiting a special educational institution, where ICTs are used to provide handicapped children access to learning and skills for future professional work in ICT environments.

Ongoing Support

The global network of the Internet makes possible individual contacts, communication, and interaction by student teachers with scientists and experts. There are thematic sites and specialized virtual conferences that facilitate intensive exchange and consultation on a wide range of topics. A search on the Internet, encouraged by the professor and stimulated by the overall environment, may become a constant and habitual activity for a teacher. During the course the student teachers often refer to their recent findings on the Internet, which they transform into new tasks for pupils, or themes for academic competitions.

Unified Information Space

Information on the Internet could be very important in a model of open education. For example, parents might gain better understanding of what and how their children are taught at school, their children's progress and attendance, agendas or results of meetings, etc. All proceedings of the courses for improving professional skills are supported in a unified information space, to which the students constantly refer while deploying their reports on completed projects, finding assignments and other information, work-planning, exchanging personal messages, making group announcements, and critiquing the development of the teaching and learning process. When a unified information space is used in this

way for educator professional development, teachers are far more likely to use such virtual spaces in their classrooms.

Opportunities for Research

When ICTs are used extensively in the teacher education programme, there are extensive opportunities for research. Students may engage in recording, analyzing, and reflecting on teaching objects and projects. The student teachers thus become reflective practitioners, who understand both the value and the methods of educational research.

A SAMPLE CURRICULUM DESCRIPTION

It has become obvious to educational communities that every teacher must be:

- competent in information and communication literacy
- adroit in using the new ICT learning tools in pedagogical work.

It is worth noting how the very goals and strategies of ICT-related teacher education have changed over the past decades.

In the early 1980s teachers and pupils learned how to operate a computer by writing and running simple programs or by using computers for data retrieval and word processing. They were not taught how to apply acquired skills to their daily problems, least of all to teaching and learning. We realized in the 1990s that solving authentic problems was an appropriate application of computers to that increased learning for students. Strange though it may seem, even after this factor method was proclaimed the highest priority, the same old attitude continued to lurk under the surface of progressive modern trends. We continued to introduce students to computers-teach them to use databases, spreadsheets, browsing and presentation packages, etc.-while providing them neither conceptual understanding nor practical experience in using these applications to enhance their own learning.

An example of this is the recent attempt to use the ICDL-the International Computer Driving License-in schools without connecting it to school life. Teachers are taught how to use the standard software designed for all office occupations (which is undoubtedly good) except

schooling. Any secretary, bookkeeper, or manager having the ICDL can quickly learn how to benefit from it in the workplace with a little help from a colleague at the next desk, who is already familiar with the small secrets of the trade in a computerized environment. Nothing of this sort is available to the ICDL-qualified teacher. Such a teacher is in an institution still at the technical level of the nineteenth century, where no computer culture exists, and where only very bright, courageous and energetic individuals have a chance to overcome such inertia. Without strong models for the effective and appropriate use of ICTs to enhance the teaching-learning process, knowledge of ICT skills will be of little value to education. For these reasons, we must teach student teachers things that are relevant to them, because only proactive, "hands-on" teaching and learning-by-doing can bring about palpable results in this field. What does this mean in the context of our endeavour?

It means that we should minimize lecturing and maximize seminars, workshops, and design sessions. It means that we should invite student teachers to assume the roles of pupils who ought to be motivated and encouraged to learn, and tutors, who teach themselves how to create a favourable atmosphere in the classroom. As a second step, we must give student teachers concrete assignments and equip them with instruments and materials to be tested in actual problem-solving situations. It has been shown quite convincingly that after such experiences teachers are more likely to seek new paths in education and encourage their pupils to do the same.

Seminars precede the design activity, or are included when the need arises. Students are told what is needed for their work just when they understand the necessity of having certain knowledge or skills. Meanwhile, the instructors demonstrate model effective practices in using ICTs in two distinct ways. In the first, they display mastery in certain ICT competencies, sharing "secrets of the craft". In the second, instructors demonstrate how to learn, assimilating new skills and/or knowledge using technology. Instances in which technological problems arise provide opportunities for the instructor to model problem-solving strategies in dealing with unex-

pected computer crashes or related problems. These are especially valuable moments, and should be analyzed in detail and all the decisions and actions taken in the process verbalized.

Table 8.1: Model Projects Activity, Selected on the Basic of Student Interest and Time Required/Available

Projects	Description	Meaning and Context
Here I am	Every student creates a personal information space – a personal site or a page on the Internet. Parts include: 'I have learned', 'My family', 'My lesson', 'My favourite musical piece', etc.	A site or a page is the means for telling a story about oneself and the results of one's activities, addressed to neighbouring and far-flung correspondents.
Here we are	Class members create a collective information space, combining individual student pages within the framework of the group project.	A feeling of belonging to a certain community and of participating in educational change; more clearly conceptualizing and articulating impressions; narrating learning events to the colleagues who are not participating in the course.
Making acquaintances	Information in beginning projects 'Here I Am' and 'Here We Are' is fed into a database, and a notebook is created in electronic and hard copy form.	Getting acquainted with peers.
School of the future	The students describe and discuss usage of ICTs in the educational process, and the results achieved with them; propose and discuss potential and future usages.	Designing the usage of ICTs within one's own school system. Conceptualizing the essence of changes in education and in world civilization.
My lesson	Each student in a micro-group prepares and gives a lesson using a slide show, distributive materials, or materials for individual work using different forms of ICTs. All proceedings are video recorded.	Making a lesson better (more efficient, interesting, visualized) by using acquired competencies.
My memory	Alphanumeric fixation of messages, photography, video recording, and audio recording.	Saving information and impressions of the process of learning for further use.
I have learned/ We have learned	Students recount the most exciting learning episode in their lives, when they acquired some valuable skill or habit. These episodes are discussed, grouped and analyzed. A matrix of skills and learning motivations is jointly created. The matrix and results of the analysis are represented within the project 'Here we are'.	Understanding what creates motivation for learning, and what the means for creating motivation are. Using the results in one's activity in designing school education.

Educational Goals	Technical Knowledge, Skills, Habits	A*	T*	C*
Self-expression, organization and presentation of relevant information in various ways.	Using general tools for constructing hyper-media objects and linking them.			
Developing the skills and habits of collective information activity in the sphere of education.	Working with hypermedia objects, recording audio and visual information.			
Learning modern models of information activity; organizing and sharing private information.	Using a keyboard, a database template, and a printer.	1	1	1
Planning of one's own individual and collective activity in the information environment of open education.	Designing screens, structuring lists, using technology for collective discussion.	6	4	6
Search, analyze, select, organize, and present information.	Using diverse forms of ICT hardware and software.	4	6	4
The skill to collect and select visual information, to pinpoint and highlight the essential.	Acquiring and storing digital photos, videos, and audio recordings.	2	4	4
The skill to reflect, deliver one's own opinion, participate in discussion, analyzing and generalizing. The skill to select and present content.	Technology of collective discussion. Using lists, tables and other ways of organizing information.	1	1	1

* Class Hours Required for: Administrator (A), Teacher (T), ICT Coordinator (C).

Projects	Description	Meaning and Context
My family	Students create compositions about their family (possible options: the family of my childhood, my present family, a family that I want to establish.)	Creation of a composition on a theme, which is emotionally important, substantial, and relevant to the student.
My school	Students create compositions about their school (possible options: the school where I've been learning, the school where I work, a school of my dream.)	Creation of a composition on an important theme, which can be used in further work.
Mathematical discovery	Each student constructs and analyzes models in a virtual mathematical laboratory (for example, Geometer's Sketchpad)	Understanding how it is possible to discover mathematical truth by oneself.
Constructing a model	Each student creates a model of a dynamic object or movable mechanism, perhaps by using a Lego construction set.	Implementation of one's design 'in metal'. The feeling of triumph in case of success: "It works!!!"
Weather and nature around us	Students observe the weather using photography and/or video recording and sensors, then compare observations with information on the Internet; forecast the weather, calculating the percentage of accurate forecasts.	Comparing objective and subjective data, exposing unexpected trends and patterns. Understanding the limits and possibilities of prediction. The idea of probability.
Physical experiment	The students build genuine and virtual laboratory settings, conduct physical and mathematical experiments, analyze results, offer and test hypotheses in both actual and virtual environments.	Making clear for oneself the sense of natural-scientific discovery, the role of experiment, mathematical modelling of natural processes, computer visualization of mathematical models.
Joint artistic work	Students create their own information object (a page of a fairy tale, a person's face, an episode of an animated movie) as a separate part of the artistic whole, which is composed by the entire group.	Reveal individual contributions and individual styles within a collaborative work of art, and appreciate that these do not contradict but enrich each other.
Joint publication	Groups create hypertext publications on the learning process or some other theme related to educational use of ICTs, using various resources including e-mail and thematic conferences.	Understanding how it is possible to compose with the help of ICTs a coherent (hyper-) text that expresses both common vision and individual approaches to problem solving.
My country. The place in which we learn and work	Students visit schools, observe nature, sightsee, and visit cultural-historical places, using photography, video, and audio recordings. One of the outcomes is to make a template for later use with schoolchildren.	Achieving important educational goals by means of a concrete project, bearing sufficient creative potential, as well as forming various aspects of the information-communication competence in live productive teaching-and-learning practice.

Educational Goals	Technical Knowledge, Skills, Habits	A	T	C
The skill to organize information, and to transmit one's thoughts and emotions to others by various means.	Creation of a hypermedia object; working with templates.	3	4	3
The skill to organize information about complex and well-known objects according to their purpose, functions, and structure.	Work with hypermedia objects; construct information objects using templates and wizards.	6	4	4
Ability to pose a question and to formulate and test a hypothesis (logically and experimentally).	Creation and analysis of a mathematical model.	2	6	4
Assimilating the design cycle.	Drawing and reading blueprints, assembling, and programming	4	6	6
Methodology of collecting and analyzing information used to predict the probability of future events.	Working with sensors, processing and presenting data using graphic and statistical instruments.	4	6	4
Methodology of natural-scientific research, description and cognition of natural phenomena and processes.	Use of ICTs for observing, recording, analyzing, and graphing data; make models.	2	6	4
Use co-operation and empathy in planning, discussing, and implementing ideas.	Create, edit, and arrange objects and images of the real world by means of ICTs.	4	4	2
Use telecommunications, record proposals made by various participants, search for compromises.	Editing hyper-texts using standard means, instruments, and protocols of group work on the Net	6	4	2
Searching, evaluating and selecting information, seeing objects from different angles, and accentuating peculiar details, etc.	Photography, video and audio recording, editing and composing; working with complex hyper-media objects.	4	6	6

Projects	Description	Meaning and Context
My (later our) Internet collection	Students search for information on the Internet; describe and evaluate sites and reflect on how sites could be used in education. Special attention is paid to the regional sites (created by local organizations, or covering related events).	Understanding what the Internet is and why it is needed.
Design a site	Each student designs an educational site (of a school, city, country) as an area of student-teacher-administrator-parent-government official interaction.	Developing the project, creating an information space of one's own educational system and its external connections.
Portrait gallery	Students create a gallery of portraits of the course participants with portraits on individual and group pages.	Fixing life moments of individual participants in global information space. Looking at them from the outside.
Family tree	Each student makes a personal family tree or uses an historical personality.	Realizing and saving historical memory for the future generations.
Statistics - who we are	Groups choose statistical indices and parameters and gather and analyze data to create pages on the site 'Here We Are'.	The idea of learners and their educational system belonging to a certain historical-cultural and socio-political entity, indexing it and allowing quantitative expression.
Problems of education	Individuals work on a text about the basic problems of education in the region and create a common text based on shared information and discussion.	Conceptualizing general and individual problems in a region, creating a coherent and comprehensible text.
The best Internet site	The students agree on an interesting information resource and, using various means of electronic expression, advertise the resource.	Criteria for analysis of information resources. Conceptualizing attitudes toward the Internet. First attempt at the business of advertising and marketing.
My Internet	Each student creates a catalogue of Internet resources.	Constructing the learner's own space for information-reference sources to be used later in school and in life; translation, if the sources are in foreign languages.
Educational products	As a group, students analyze various educational products using digital electronic technology.	Understanding the basics of the national and world market of educational software and Internet services.
Computer Guru	An optional activity of learning a specific ICT tool or tools in great detail.	The feeling of mastery, helping colleagues in important and complex tasks.
Hours total		

Educational Goals	Technical Knowledge, Skills, Habits	A	T	C
Comprehending the scope, potential, and limitations of the Internet.	Using search-engines, evaluating and integrating data retrieved from different sources.	4	6	6
Forming the idea of the educational process in an open environment.	Using templates and information sub-systems in educational interaction.	6	6	6
Choosing a portrait and supplementing it with explanatory notes.	Using digital cameras and digital image processing.	4	4	4
Recording information, selecting important, interesting, substantial items.	Audio and video recording, editing.	4	4	4
Numerical representation of student types. Methodology and mathematics of statistics.	Spreadsheets and visualization of statistical data.	4	4	4
Expressing thoughts clearly and succinctly to improve what is already created in a series of iterative approximations.	Word-processing.	6	2	4
Modelling the general traits of human perception; forming one's own ideas on the impact of the Internet.	Graphics editing.	4	4	4
Organization of information spaces; evaluation of sources; principles of working on a foreign language text.	Catalogues, filing systems, subscriptions, conferences, chats, and translators.	2	4	4
Working out ideas about the features of and evaluation criteria for modern information resources.	Standard and non-standard mechanisms of program systems.			
Learning a new set of skills.	General and specific ICT tools.			
		38	96	78

Table 8.2: ICT Training in the Form of Instructor-Led Seminars

Theme	Brief description	Hours
Technical safety in working with ICTs	Electrical safety. Measures to prevent harmful effects of ICTs upon human beings. Rules for connecting power lines and for grounding.	0.5
Medical-hygienic requirements for the organization of work with ICTs.	Acquaintance with health norms for working with computers. Hygienic requirements for the equipment. Preventive health gymnastics for the eyes, wrists, spine and neck muscles.	0.5
Turning the computer and peripherals on and off.	On/off buttons, menu entry 'Quit'. The order of connecting external devices.	0.5
Elements of construction and the functional principles of computer and other ICTs.	Measurement, digitizing images and processes, electronic sensors, information storage, memory volume, magnetic carriers. Transmitting and receiving information, electrical signal, speed of transmission. Digital cameras, scanners. Processor, speed of work. Representation of information, screens, projectors, printers.	2
The skills of working in a graphic operational environment.	Program window and its main elements. Programme menu. Command palette.	1
Information security and human rights.	The purpose of the access procedures. Computer viruses and how to fight them.	0.5
How the Internet is organized.	General information about the organization of the Internet. Server, client, provider. WWW-service. The meaning of protocols and rules. Registration of one's name.	1
Information searching on the Internet.	Acquaintance with search-engines and the rules of enquiry.	2
Creating an Internet site (hypertext multimedia publication).	Environments to create sites. Creating a site using templates.	2
Electronic mail.	Why electronic mail becomes the basic means of communication. Work with mailing programs.	1
How to organize one's own individual information space.	Folders and files. Tree-like structure of information storage.	2
Creating multimedia presentations.	Rules of public presentation using a screen. Presentation without a presenter.	1
The basics of text input with ten finger touch-typing.	Working with a computer typing tutor to obtain basic skills of text input through the keyboard by using ten-finger touch-typing.	5
Input and processing of sound.	Rules for using microphone and mixing panel, musical keyboard, processors for sonic and musical editing.	1

Theme	Brief description	Hours
Photography, the possibilities of digital photography.	Basic photography skills. Transferring images from camera to computer. Image processing by dot-matrix graphic editor.	1
Graphics. Creating and editing images.	Creating images by using graphic editor, vectoral graphic editor, and graphic pad.	1
Video shooting aided by various devices and editing.	General skills of video shooting. Using web-camera for video shooting, video emailing, and video editing.	1
Computer animation: creation and areas of application.	Technology to create animation. Editors to process animated images.	1
Scanner-Information input by means of a scanner.	Practical skills with a scanner.	1
Printer-Information output.	Practical skills with a printer.	0.5
A structure of educational information resources.	Acquaintance with a modern classification system of educational information resources.	0.5
Installing educational software.	Rules for installing information resources.	0.5
The range of devices to be connected to a computer and its educational applications.	Acquaintance with the whole spectrum of devices to be connected to a computer and its classification: printer, scanner, digital camera, graphic pad, and various sensors.	0,5
Distinguishing features of information.	Principles of what makes up information. Text as a discrete representation of information. Distinct features of sound and visual images. The advantages of digital storage, processing, and transmission of information.	1
Electronic interpreters.	Acquaintance with electronic interpreters and electronic glossaries. Interpreting sites on the Internet.	1
Algorithms of activity and programming languages.	Acquaintance with the Logo program language.	1
Mathematical informatics.	How computers work: program and data.	1.5
How a computer is constructed.	Memory and processor, what is meant by a 'good computer', saving information.	1
LEGO brick computer and sensors-feedback.	Acquaintance with an environment for controlling a microcomputer and its capacities to collect and analyze information.	1

Table 8.3. Analysis of Educational Information Resources

Students select and analyze information resources from the point of view of pedagogical expediency and reflect on the possible scenarios for their use.

Theme	Brief description	Hours
Analyze educational information resources using a questionnaire.	Students analyze several information resources of various types using data from questionnaires and select one suited for the learning objective.	2
Create a lesson plan using information resources.	Students develop a lesson plan in which selected information resources are used.	2
Conduct an exemplary lesson using information resources.	The students conduct a lesson or a part of a lesson using information resources according to independently developed plans.	2

Table 8.4. Time Estimate for Course Activities

On the assumption that the Introductory Course would occupy the first semester, the possible syllabus might be as follows.

Module	Allocated Time
"My Name"	2 hours (first encounter with computers for those who have never used them before)
Introductory Course	
Stage One	8 hours
Stage Two	16 hours
Stage Three	8 hours continued through the whole course, 8 hours per semester (average)
An example of time allocation from a few other modules:	
"My Personal Address Book" (elementary exercises with text objects, databases, printing-out)	4 hours
"My Family"	12 hours
"My Country"	12 hours per semester
"My Learning and the Teaching of My Pupils"	8 hours per semester

Table 8.5. Reflective Analysis of Activity and Situation

In the process of reflection, teachers use the methods and technical means for organizing collective activity: audio recording, typing of the proceedings' theses, projected on a large screen, distributing resumes via electronic mail among all students, group or individual.

Theme	Brief description	Hours
Modern civilization. Open society. Role of ICTs, the Internet.	While developing the projects, the elements of the students' and professors' activities are pin-pointed and discussed to a degree of detail which could be impossible without contemporary ICTs.	2
Open education.	The elements of students' and professors' activities, characteristic of open education, are revealed.	2
General goals of education.	The problems of the course work and further applications of its results are discussed within the context of the general goals of education.	3
New values of education. Information-communicative competence, new literacy.	Students reveal and formulate elements of information-communicative competence in general terms, irrespective of concrete technological instruments.	3
Possible variants of using information technologies in education.	In connection with all examples of educational ICT-usage, which the students learned from visiting the schools, participating in workshops, and watching videos, students are asked: "How do you envision ICT use in your teaching practice?"	2
How information technologies create change in education.	Special emphasis is given to the question about shifting priorities in content and methods of education in relation to the changing world, including the advent of modern information and communication technologies.	2
Unified educational space for the school, city, region, and country.	Collaborative creation of the concept of information flow in relation to education, and the place and role of teachers and schoolchildren participating in the direction of these flows.	2
Project-based approach in education. Goals and methods of organization of activity.	Constant emphasis on design elements in all types of activity. Management of design activity in educational systems and concrete teaching and learning endeavours.	3
Educational practice.	Joint project-based search for the answers to the concrete questions in relation to normative base, financing, human resource, etc.	2
Levels of 'informatization'.	Discussion on how to represent visually the developmental level of an information environment in a given school and/or region.	

Theme	Brief description	Hours
Designing a unified educational information environment.	Working out the programme for the development of an information environment for the student's own educational institution and/or region.	
Playing, teaching, and learning.	Discussing the playful, emotional and motivational moments in teaching and learning process.	2
Reflection upon the process of teaching and learning in authentic situations.	Open space for reflection and project-based discussion, which is created by the students themselves.	

Table 8.6. List of Equipment Needed for Programme Implementation (for a Group of 16 Students)

The following is the optimal array of equipment to support the curriculum. Many of the elements of the curriculum could be accomplished without all of the following equipment items.

Equipment Item	Quantity
Computers, connected to unified network with access to the Internet	16
Scanner	4
Printer black and white, networked	1
Printer colour	2
Graphic pad	16
Web video camera	16
Digital camera	4-8
Digital video camera	1
Microcassette recorder	4-8
Microphone	16
Musical keyboard	2-4
Set of sensors	8
Robotics kit (such as RoboLab)	8
Multimedia projector	1
Device for feeding images from marker board into computer	1

Table 8.7. Teaching and Learning in Educational Institutions that Display Efficient Use of ICTs

Students discuss their experiences with teachers and schoolchildren, recording in various ways the information of interest to them. Simultaneously, students collect information for the project on local issues.

THEME		Brief description	Hours
1	Use of ICTs in various classes.	Students visit various subject matter classes in which ICTs are used efficiently and in a wide variety of ways to acquire practical acquaintance with the activities of schoolchildren using ICTs.	4
2	Open information-educational space of school.	School visits provide a conceptual understanding of an open information-educational space. During the visits, students get acquainted with various forms of organization of the open space Teacher-Student-Parent-Administration-Local Community-World community.	4

GLOSSARY

Acceptable Use Policy

A statement of the procedures, rights and responsibilities of a user of a technology solution and any disciplinary procedures that will be enforced for misuse of the technology.

Active Learning

The learner interacts with the teacher, author, or the learning programme to construct his/her own meaning. It is the child's individual or meta-cognitive act of observation, hypothesis generation and testing, and reflection.

Administrative Software

Computer programs that are used to expedite the storage and use of education data for efficient functioning in education settings. Examples are student records systems, personnel records systems, and transportation mapping packages.

Analog

The representation of information by continuous wave forms, frequencies or bandwidth that vary as the source varies. Information represented and transmitted in the form of a continuous electromagnetic wave (contrast with digital).

Application Software

Computer programs that are used to accomplish specific tasks not related to the computer itself. Examples are word processors, spreadsheets, and accounting systems.

Artificial Intelligence (AI)

Computer programs written that attempt to emulate the decision-making capabilities of the human mind.

ASCII

American Standard Code for Information Interchange. An eight-bit standardized binary code used by most teletypewriters and display terminals.

Assessment

A broader term than paper and pencil testing that includes all types of activities that can be used to have learners demonstrate their ability to perform.

Asynchronous Communication

A time-delayed communication through some type of recording device. It is replayed at the convenience of the user. An example is e-mail. Communication in which interaction between sender and receiver does not take place simultaneously (e.g. e-mail or fax).

Authentic Performance Assessment

The major goal of authentic performance assessment is to assess the ability to apply knowledge to solve real-life problems. These types of assessments, at least insofar as general descriptions are concerned, approach the learner as more active. The student must take considerable control over the assessment through planning and applying knowledge in perhaps new and different ways. Proponents of these methods claim, too, that they reach more complex cognitive skills.

Authoring Software

High-level computer programs designed for creating computer-based training, interactive presentations, and multimedia. Commands are often presented as simple terms, concepts, and icons. Authoring software translates these commands into programming code.

Bandwidth

The amount and rate of transmission capability of an electronic device. This is the transmitted signal in different ranges of frequencies (highest to lowest), measured in cycles per second (hertz) for analog signals and bits per second (bauds) for digital signals. Wires and cables are used mostly for voice communications, which require a narrow bandwidth. It is the range of frequencies that can be carried by a telecommunications carrier (e.g. telephone lines, satellite transmissions, and computer-based systems).

Baud

A unit measuring the digital transmission speed of any device. One baud equals one bit per second (bps). 300 baud is low while 56,000 baud is faster. It is used in binary telecommunications transmission.

Bit

The smallest unit of information a computer can use. A bit is represented as a "0" or a "1" (also "on" or "off"). A group of 8 bites is called a byte. Bits are used to measure the speed of digital transmission systems. Speeds are commonly expressed in kilobits (KBPS), megabits (MBPS), and gigabits (GPS) per second. In an electrical communication system, a bit is typically represented by the presence or absence of a pulse.

Broadband

A term often used to describe a range of frequencies wider than that required for just voice communications. Also, a term used to describe systems and equipment with wide bandwidth that can carry these ranges of frequency.

Browser

Software that lets you locate, view, and retrieve information on the World Wide Web using a graphical interface.

Bulletin Board System (BBS)

A network-based system that is used to store and access messages, programs or data by anyone having access to the system.

Byte

The amount of memory space needed to store one number, letter or symbol in a computer.

Cables

The collections of wires twined together to connect peripherals to the computer system unit.

CAI

Computer-Assisted Instruction. Instruction mediated by computer in which the system allows for remediation based on answers but not for a change in the underlying program structure.

Carrier

A signal with known characteristics-frequency, amplitude, and phase-that is altered or modulated in order to carry information. Changes in the carrier are interpreted as information.

Case Study Method

Students have to deal with a real or imagined problem situation. They study the case, then identify the general principles that underlie the case. The students then test these principles on other case examples for verification of their general validity.

CBT

Computer-Based Training. Instruction primarily delivered by computer, with a more complicated branching program of remediation and answering. (See Hypertext media).

CD-ROM

Compact Disc-Read Only Memory. A round, silver plastic disk that comes with massive amounts of information embedded and ready to be used. Unlike diskettes, any type of computer with a CD-ROM drive can read CD-ROM disks.

Central Processing Unit (CPU)

The brain of the computer that processes instructions and manages the flow of information through a computer system.

Client/Server Network

A configuration where all users store their files on a central computer, and files are accessed directly from where they are stored on the central computer. The central computer is the server, and the client is the computer that can access the information from the central computer.

CMC

Computer-Mediated Communication. A typed communication method that offers private but narrow channel of communication.

Codec

An electronic device that converts analog video signals into a digital format for transmission, and vice versa. The name is abbreviated from "coder-decoder" or "compressor-decompressor" when compression is also involved. The codec is the electronic black box needed to make the conversion.

Cognitive Apprenticeship

A term for the instructional process that teachers provide and support students with scaffolds as the students develop cognitive strategies. It permits peers to learn through their interactions, to build stories about common experiences, and to share the knowledge-building experiences with the group.

Cognitive Learning Theories

Focus on explaining the development of cognitive structures, processes, and representations that mediate between instruction and learning.

Cognitive Strategies

An individual's skills for "learning how to learn."

Collaborative Learning or Cooperative Learning

Students of varying abilities and interests work together in small groups to solve a problem, complete a project, or achieve a common goal.

Compressed Video

Video images in digital form that allow redundant information to be eliminated, thereby reducing the amount of bandwidth needed for their transmission. The amount of compression (i.e. bandwidth determines the picture quality).

Compression

A technique to remove all redundant data from video images or computer files for the purpose of easier storage and transmittal. Analogous to condensed juice. All of the pulp (noise) and water is removed. The remainder is frozen and shipped. At the desired moment, the signal is decompressed for playback.

Computer-based Instruction

Computer programs that teach or reinforce concepts and skills.

Computer Conferencing

Interactive sessions between networked computers whereby data, documents, and/or video and audio are shared. The term encompasses both data conferencing and desktop video conferencing. Web chat, whiteboards, and web-based conferencing may be used in computer conferencing.

Computer Type

The classification of a computer according to its storage and computing capacity, the number of users that can be supported, the variety of input and output options, and the physical size. Three major types of computers are mainframe computers, minicomputers, and microcomputers.

Constructivism

The learner constructs knowledge; learning is a personal interpretation of experience; learning is active, collaborative, and situated in real-world contexts; and assessment of learning is integrated within the learning context itself.

Contention

A method of line control in which the terminals request to transmit. If the channel in question is free, transmission goes ahead; if it is not free, the terminal will have to wait until it becomes free. The computer may build up the queue of contention requests, and this can either be in a prearranged sequence or in the sequence in which the requests are made.

Courseware

Instructional materials in a complete mediated format. May refer to a single instructional component, such as a computer-assisted instruction program, or a multiple instructional entity, such as guidebooks, videodiscs, and computer-assisted instruction.

Criterion-Referenced Tests

Define a learner's performance in terms of specific competencies or objectives mastered.

CSCL

Computer-Supported Collaborative Learning. Area of work that focuses on socially oriented theories of learning using computer technologies to support collaborative methods of instruction.

Curriculum (plural curricula)

A plan of instruction that details what students are to know, how they are to learn it, what the teacher's role is, and the context in which learning and teaching will take place.

Curriculum frameworks

Describe what should be taught in order for students to acquire certain skills.

Cybernetic Learning Environment

Emphasizes mutual interaction between the learning system and the learner-interaction in which the learner negotiates control of the learning experience with the system and the system attempts to respond intelligently to the explicit and implicit needs of the learner by adjusting to a changing multidimensional portrait.

Data Base Software

The computer programs that allow the storage of large amounts of information and give the capacity to search, retrieve, sort, revise, analyze and order data

quickly and efficiently. There are two types of databases, flat file data-bases and relational databases.

Declarative Knowledge

Requires a learner to recall in verbatim, paraphrased, or summarized form facts, lists, names, or organized information. Also described as "knowing that".

Dedicated Lines

Telephone lines leased for a specific term between specific points on a network usually to provide certain special services not otherwise available on the regular or public-switched network.

Design

A systematic or intensive planning and ideation process prior to the development of something or the execution of some plan in order to solve a problem.

Desktop Videoconferencing

Videoconferencing on a personal computer equipped with a fast Internet connection (at least 28.8 Kbps modem), a microphone, and a video camera. There can be two-way or multi-way video and audio depending upon the hardware and software of participants. Most appropriate for small groups or individuals.

Digital

Data is represented as discrete units (on/off) rather than continuous as in analog signals. All information is encoded as bits of 1's and 0's that represent on and off states. Digital signals are always in a state of on/off. They are less susceptible to interference and noise and can be stored and manipulated by a computer. It is contrasted with analog. Once data is digitized, it can be stored and changed. Information stored in the form of bits (on/off signals) and which can be stored and transmitted via electronic media.

Directed Instruction

A teaching and learning model based on behavioural and cognitive theories; students receive information from teachers and do teacher-directed activities.

Discovery Sequence

Learners often take on more of the processing responsibilities, engaging cognitive strategies as well as domain knowledge.

Disk

A round plastic magnetic device on which computer programs and data are saved. There are three main types of disks: hard disks (maintained inside the computer), diskettes (a.k.a. floppy disks), and compact disks.

Disk Drive

A device that reads the information contained on a disk. The drive may be permanently installed inside the computer (hard disk drive) or contain a slot for entering the disk from outside the computer (floppy disk drive or compact disk drive).

Diskette

A thin, plastic flexible disk on which computer programs and data can be saved outside of the computer. The two types of diskettes are 3.5-inch disks that come in a hard plastic case and 5.25 inch disks that come in thin pliable (floppy) cardboard-like cases.

Distance Education

A subset of distance learning that includes evaluation by distance educators and two-way communication, which usually includes the structuring of media content and use by the educator.

Distance Learning

Using some electronic means (e.g. modems, satellite transmissions) to make possible teaching and learning at separate sites.

Distributed Learning

A system and process that uses a variety of technologies, learning methodologies, online collaboration, and instructor facilitation to achieve applied learning results not possible from traditional education in a truly flexible, anytime/anywhere fashion.

Downlink

A television dish used to capture signals off a satellite transponder for distribution in a local area.

Download

The process of transferring (copying) data files from a main host computer to a smaller computer. It is the opposite to upload.

Drill and Practice

An instructional software program that presents items for students to work (usually one at a time) and gives feedback on correctness; designed to help users remember isolated facts or concepts and recall them quickly.

Educational Technology

The combination of instructional, learning, developmental, managerial, and other technologies as applied to the solution of educational problems.

Electronic Mail

Email (electronic mail) is messages stored and sent via a computer system, transmitted across networks typically accessible only by the addressee.

Electronic Mail (e-mail) Software

The computer programs that facilitate computer-to-computer communications among users in any location.

Ethical Standards

Guidelines for the appropriate use of the technology solution and the maintenance of privacy of the contents of the system. These are generally specified in an Acceptable Use Policy, particularly where there is concern about the security of the system or the availability of objectionable materials obtained through the system.

Experiential Learning

A learning situation is set up which presents a problem or a complex task for the learners to deal with. The learners are encouraged to draw general conclusions and establish general principles that may explain or predict across a range of similar situations.

Expert

An individual who has experience, knowledge, and expertise relative to the context, learner, and instructional task.

Expert Systems

Knowledge databases that are sorted and selected by an algorithm programmed with a set of rules derived from an expert. The systems help to formulate solutions to problems. In education, future possibilities include the development of expert systems to aid in making instructional design decisions based on current databases of instructional research. Therefore, an optimal instructional strategy can be recommended for implementation.

Fiber Optic Cable

Hair thin, flexible glass rods that use light signals to transmit information in either analog or digital formats. Fiber optic cable has much higher capacity than copper or coaxial cable, and is not as subject to interference or noise. Fiber optic cable has the bandwidth to accommodate high-speed, multimedia networking.

File

A block of information stored on a magnetic media such as a floppy or hard disk or a tape. A file may contain a computer program, a document, or a collection of data.

File Server

A special computer that stores dedicated data such as pictures, slides, or video clips. It can be accessed by other computers to retrieve these data.

Firewall

A firewall is a security system for computers. Computers 'behind' the firewall can access other computers on the Internet but Internet computers are prevented from accessing any computer behind the firewall.

Floppy Disk

See Diskette.

Flowchart

Visual representation of procedures for performing a task.

Formative Evaluation

Evaluation of materials to determine the weakness in instruction so that revisions can be made to make instruction more effective and efficient.

Frame

Two complete scans of the video screen at 1/30 second. A frame is composed of two fields (each 262 lines). A single frame is a standard CAV videodisc reference point. There can be as many as 54,000 addressable frames on one side of a CAV videodisc.

Frequently Asked Questions (FAQs)

A listing of questions typically asked along with the answers to the questions. This list is prepared to help novice users as they begin to use computers or software.

FTP

File Transfer Protocol. This is a protocol to allow the transfer of files from one computer to another over a network. One computer will run an ftp server, which allows people on other computers to run ftp client programs to connect to it, upload, and download files.

Functional Specifications

A document that states in detail what a new (or upgraded) computer system should be expected to do, i.e., what services it delivers to those who will use and maintain it. This listing of a computer system's capabilities can be compared to what can be bought from a commercial vendor or built by developers.

Functions

The tasks or actions that software is intended to perform.

Funding Proposal

A proposal to a funding agency which contains the following elements: a need or needs to be addressed, a vision or solution to address the need, goals and objectives, a plan to achieve the objectives and goals, a budget and timelines, and a plan for evaluating progress in achieving the goals.

Gantt Chart

A diagram that shows tasks and deadlines necessary for completing a project.

Generative Instruction

Those approaches in which learners encounter the content in such a way that they are encouraged or allowed to construct their own idiosyncratic meanings from the instruction by generating their own educational goals, organization, elaborations, sequencing and emphasis of content, monitoring of understanding, and transfer to other contexts.

GIF

Graphics Interchange Format. A standard format for compression of images. Images on web pages are commonly stored in the GIF or JPEG formats.

Gigabyte

One million bytes.

Goals

General statements of intent. From goals, objectives are derived.

Groupware

A computer software program that allows the same information to be shared among several computers simultaneously. With some applications, users can see each other and from their own computers, add to or edit text and graphics in a single document.

Group Investigation

Each student in a group selects a topic, researches it, and then shares his or her findings with the group. The topics are then combined into a joint group report.

Hard Drive (a.k.a., hard disk drive)

A device used to "permanently" store information within a computer, such as programs and data.

Hardware

The computer equipment used to do the work (i.e., operate software programs). It consists of the items you can touch, such as the computer case and the peripherals (e.g., monitor, keyboard, mouse) that are attached to the computer.

Higher-order thinking

Understanding difficult concepts and applying sometimes conflicting information to solve a problem (that may have more than one correct answer)

HTML

Hypertext Markup Language. Coding used to publish documents on the World Wide Web that allows links to information in files on any computer connected to the Internet.

Hyperlink

A connection among documents in a hypermedia or hypertext format.

Hypermedia

An approach to information storage and retrieval that provides multiple linkages among elements. It allows the learner to navigate easily from one piece of information to another. The storage and retrieval of text, images, audio, and video in computer (digital) form.

Hypertext

The linking of information together by highlighted key words that have been marked up creating paths through related material from different sources such as footnotes and encyclopedias. It is the ability to present connected documents.

Icon

A symbol displayed on the computer screen that represents a command or program. Icons help make computer operating systems and applications easier to use.

ICTs

Information and communication technologies.

Implementation Project Manager

The person who directs the installation and implementation of a technology solution.

In-service Teacher Education

Professional development training provided to certified practising teachers.

Instruction

Intentional facilitation of learning toward identified learning goals.

Instructional Design

The systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation.

Instructional Development

A self-correcting, systems approach that seeks to apply scientifically derived principles to the planning, design, creation, implementation, and evaluation of effective and efficient instruction.

Instructional Software

The computer programs that allow students to learn new content, practise using content already learned, and/or be evaluated on how much they know. These programs allow teachers and students to demonstrate concepts, do simulations, and record and analyze data. Often administrative applications like database programs and spreadsheets are used within the instructional context to help analyze and present information.

Instructional Strategies

Covers the various aspects of sequencing and organizing the information and deciding how to deliver it.

Instructional Systems Development (ISD)

Design models and processes for the analysis, design, development, implementation, and evaluation of instruction.

Instructional Technology

The systemic and systematic application of strategies and techniques derived from behaviour and physical sciences concepts and other knowledge to the solution of instructional problems.

Integrated Learning System (ILS)

A network that combines instructional and management software and usually offers a variety of instructional resources on several topics.

Intellectual Skills

Students learn not only how to recall, but also how to apply knowledge to instances not encountered during instruction.

Intelligent CBI

Sophisticated artificial intelligence tools that have the potential to create new models and instructional strategies for CBI (Computer-Based Instruction). Bayesian probability models provide efficient means of identifying mastery of objectives and formulating a sequence of lessons for individual students that are tailored by the programming.

Interaction

Exchange of information, ideas, and opinions between and among learners and teachers, usually occurring through technology with the aim of facilitating learning.

Interface

A general term used in the computer world to designate the hardware and associated software needed to enable one device to communicate with another or to enable a person to communicate with computers and related devices. A user interface can be a keyboard, a mouse, commands, icons, or menus that facilitate communication between the user and computer. Interface means the connection between a computer and the person trying to use it. It can also be the connections required between computer systems so that communication and exchanges of data can take place.

Internet

A worldwide network of computer networks through which people can exchange data and communications.

Internet Service Provider

A company that provides access to the Internet, such as phone companies and other commercial service providers.

ISDN

Integrated Services Digital Network. A digital phone line that can transmit data, video and voice.

IT

Information technology.

JPEG

Joint Photographic Expert Group. This is a means of compressing and storing video and high-resolution colour pictures. It is the standard for data compression of all still images.

Just in Time (JIT)

A term used to describe a system or information that is available for the user at the exact time the user needs it.

K-12

Kindergarten through the twelfth grade (secondary education).

Keyboard

A device similar to a typewriter that is used to enter information and instructions into the computer. In addition to letter keys, most keyboards have number pads and function keys that make the computer software easier to use.

LAN

Local Area Network. The linkage of computers and/or peripherals (e.g. printer) confined to a limited area that may consist of a room, building or campus that allows users to communicate and share information.

LCD

Liquid Crystal Display. A way to make letters and numbers appear on a crystal display surface as seen in pocket calculators and computers. The LCD can also project video images from an overhead projector.

Learner-Centred Classroom

Students are encouraged to choose their own learning goals and/or projects, based on the belief that people have a natural inclination to learn; learn better when they work on authentic tasks; benefit from interacting with diverse groups of people; and learn best when teachers understand and value difference in how each student learns.

Learner Characteristics

Factors in a learner's background that impact the effectiveness of their learning.

Learner-controlled Instruction

A mode of instruction in which one or more key instructional decisions are delegated to the learner.

Learning

The relative permanent change in a person's knowledge or behaviour due to experience.

Learning Task Analysis

A list of goals that describe what the learners should know or be able to do at the completion of instruction and the prerequisite skills and knowledge that the learners will need in order to achieve those goals.

Level of Interactivity

The potential for interaction prescribed by the capabilities of videodisc hardware and external intervention.

Listserv

A special interest discussion group that corresponds via e-mail. A predetermined group exchange messages in an area of shared interest. A message is posted on a list server and is automatically sent to all members of the group. A listserv is different from newsgroups in that an individual must subscribe (sign on) to participate in a listserv group.

Log On

To initially connect to a computer.

Mainframe Computer

A large computer that supports many users and has the storage and computing capacity needed for large data sets. It generally stores data on large reel-to-reel magnetic tapes that require extensive physical storage space. Users of main-

frames use dumb terminals or "tubes" that have screens and keyboards to connect to the mainframe.

Maintenance Agreement

A contract with an outside service or agency to fix a computer system (or its components) when it breaks, or assist with upgrades to the system.

Megabyte (MB)

The amount of computer memory needed to store 1,048,576 characters, which is approximately equal to one novel. Megabytes are used to describe the amount of memory on a hard disk or in random access memory.

Megahertz (MHz)

A measure of the clock speed of a central processing unit expressed in millions of cycles per second.

Memory

Storage locations in the computer, in RAM or ROM.

Metacognition

The process of thinking about and regulating one's own learning. Metacognitive activities include recalling/reviewing what you already know about a topic, identifying gaps in your knowledge, planning strategies to fill those gaps, assessing the relevance/importance of new information, and revising your beliefs about the topic.

Microchip

A silicon wafer or chip with thousands and tens of thousands of electronic components and circuit patterns.

Microcomputer (a.k.a. Personal Computer or PC)

A small computer that is desktop size and uses a microprocessor chip (the brains of the unit) to run the computer. Only one person generally uses it at a time, but it can be networked to provide communication with other PCs, mainframes and minicomputers. Both Macintosh and IBM-compatible computers are considered a part of this category of computers.

Mission Statement

A statement that outlines the vision.

Modelling

Demonstrating to a pre-service teacher or student how to do a task with the expectation that the student will copy the model. Modelling often involves talking about how to work through a task or thinking aloud.

Modem

A device that allows two computers to communicate over telephone lines. It converts digital computer signals into analog format for transmission. A similar device at the other end converts the analog signal back into a digital format that the computer can understand. The name is an abbreviation for "modulator-demodulator." This device connects the computer to a telephone line for communication with another remote computer or information network. Modems may be internal or external to the computer case. Modems are classified according to the speed with which they send and receive information.

Monitor

A device similar to a television screen that receives video signals from the computer and displays the information for the user.

Mouse

A hand-held pointing device (used on top of a desk) that gives directions to the computer and moves information around on a monitor screen.

Mud

Multi-User Dungeons/Domains. This is a virtual world in which you can interact with other participants in real time. Generally text-based, more and more visual material is being used.

Multimedia

A computer with a mixture of media such as CD-ROM, speakers, etc. Evolved from hypertext and hypermedia. It is a synthesis of computer, television, telephone, and/or fax through the computer. The integrated use and display of visual images, motion, sound, data, graphics, and text, with the user being able to interact creatively with the display.

Multimedia Systems

Include technology such as CD-ROMs and laserdiscs. This technology provides a gallery of images and programming in an accessible format. Advances in screen resolution have made possible the effective use of these applications.

Multipoint

Communication configuration in which several terminals or stations are connected. This differs from point-to-point, where communication is between two stations only.

Narrowband

Lower level frequency signals such as the telephone (3000 Hz) or radio signals (15,000 Hz). It implies a speed of 56 Kbps.

Needs Assessment

An evaluation of the existing environment and a description of the functions you want the technology to have and the needs you hope technology will meet.

Needs Statement

A description of the functional needs, technical requirements and security and ethical standards that need to be met by a technology solution.

Negative Transfer

The application of prior knowledge to situations in which it is not applicable.

Netiquette

This is the etiquette used during communications on the Internet.

Network

A group of computers connected to each other to share computer software, data, communications and peripherals. Also, the hardware and software needed to connect the computers together.

One-way Video

A video signal is received at a field site. The student can see the instructor but the instructor cannot see the student. There is two-way audio (telephone) between the instructor and the students at field-sites. Students can communicate via a telephone bridge among the sites and between the instructor and sites.

Online

The status of being connected to a computer or having information available through the use of a computer.

Operating System Software

The electronic instructions that control the computer and run the programs. This software is generally specific to a type of computer.

Optical Fiber

A thin, flexible glass fiber the size of a human hair that can transmit light waves capable of carrying vast amounts of information.

P-12

Pre-kindergarten through the twelfth grade.

Packet Switching

A technique of switching digital signals with computers wherein the signal stream is broken into packets and reassembled in the correct sequence at the destination.

Paradigm

An overall concept accepted by most people in an intellectual community about a complex process or ideas such as "school".

Pedagogical

Of, relating to, or befitting a teacher or education, especially with regard to a process of learning.

Peer-to-peer Network

A configuration where people store their files on their own computers, and anyone on the network can access the files stored on the other networked computers.

Performance Assessments

Testing complex, higher-order knowledge and skills in the real-world context in which they are actually used, generally with openended tasks that require substantial time to complete.

Performance Objective

A detailed description of what students will be able to do when they complete a unit of instruction.

Performance Technology

Comprises instructional technology and incorporates the design of noninstructional solutions to human performance problems.

Peripheral

A device that is attached to a computer, such as a monitor, keyboard, mouse, modem, CD-ROM, printer, scanner, and speakers.

Physical Security

Measures that must be taken to prevent theft, vandalism, and other types of harm to the technology equipment.

Platform

The computer hardware and operating system software that runs application software.

Portfolio Assessment

A portfolio is defined as a purposeful collection of student work that exhibits to the student and others the student's efforts, progress, or achievement in a given area. This collection must include 1) student participation in selection of portfolio content, 2) the criteria for selection, 3) the criteria for judging merit, and 4) evidence of student self-reflection. Portfolios, even more so than other forms of performance assessment, call on the learner to be highly involved in planning the entries, choosing what to include, and providing the rationale behind those decisions. Portfolios thus attempt not only to assess the end products, but to some extent, the process that went into creating them as well.

Pre-service Teacher Education

Initial education or preparation of individuals prior to their being certified and becoming practising teachers in schools.

Printer

A device that translates signals from a computer into words and images onto paper in black and white or colour. Printer types include dot matrix, ink jet, laser, impact, fax, and pen and ink devices.

Problem-solving

Refers to a learned capability involving selection and application of multiple rules.

Product Evaluation

Refers to the assessment of instructional materials that have been recently produced and have some potential use in other settings.

Project-based Learning

Each group is assigned a project, or chooses one. They collaborate to complete the project, detailing their basic goals and objectives, timeline, budget, etc.

Project Management Software

Software programs that provide tools to help manage projects, such as integrated calendars, report generators, scheduling, charting, tracking, prioritizing, etc.

Project Team

The group of persons responsible for carrying out the successful implementation of the technology solution.

Protocol

A formal set of rules or procedures by which computers communicate with each other and transfer information. Standard protocols allow different types of computers and software programs to communicate with each other. Protocols are also the set of standards and rules that let networked computers communicate or share information, such as Ethernet or token ring.

Psychomotor Skills

Coordinated muscular movements that are typified by smoothness and precise timing.

RAM

Random Access Memory. The space in the computer on which information is temporarily stored while the computer is on.

Real Time

A real-time computer system may be defined as one that controls an environment by receiving data, processing them, and returning the results sufficiently quickly to affect the functioning of the environment at that time.

Resolution

The clarity of the images produced on a monitor screen.

RGB

Red, green and blue. The primary colours mixed on a television and computer screen.

Role Playing

A type of simulation in which team members, sometimes with the aid of computers, act out roles as parts of the problem being analyzed. For example, one member of the group could act out the role of editor; another could be a reporter, etc.

ROM

Read Only Memory. A permanently stored memory that is read and not altered in the operation.

Router

A device that regulates network traffic as its enters another network, and makes sure that messages go to the correct network site.

Scaffolding

The cognitive processing support that the instruction provides the learners, allowing them to learn complex ideas that would be beyond their grasp if they depended solely on their own cognitive resources, selectively aiding the learners where needed.

Search Engine

A tool used to search the Internet for information. It searches a defined database. A word or phrase is entered on a search engine and a number of "hits" will appear. Different search engines use different search strategies. By clicking on the term, you will be brought to that Web page.

Security

Protection from threats to the equipment, functioning and contents of a technology solution.

Self-paced Learning

Education in which the learner is on their own, studying without interaction with others. Sometimes used to refer to asynchronous modes of delivery. CBT has been the most common form of self-paced learning, but web-based asynchronous systems are catching up quickly.

Simulation

Software that enables the user to experience a realistic reproduction of an actual situation. Computer-based simulations often substitute for situations that are very costly or high risk.

Site

These are related pages on a Web server. A site is entered through a home page.

Smart Card

A small plastic card containing information that can be read by a computer scanning device.

Software

Stored digital information on magnetic disks or tapes or as electronic information in the computer's memory that determines what the computer does. Software can be divided into two groups, operating system software and application software.

Software Features

The capabilities offered by software that make it easy and effective to use.

Steering Committee

A group of persons who meet periodically to evaluate the progress and success of the implementation of the technology solution.

Streaming

Playing video or sound in real time as it is downloaded over the Internet. Data is decompressed and played (by use of a web browser plug-in) as it is transferred to your computer over the World Wide Web. Streaming requires a powerful computer and fast connection since the file is not stored on your computer.

Suite

A collection of software programs that are sold together and are supposed to work together efficiently and use similar commands.

Summative Evaluation

The process of collecting, analyzing, and summarizing data to present to decision makers in a client organization in order to make judgments regarding the effectiveness, and perhaps appeal and efficiency, of the instruction.

Surfing

Exploring locations and scanning the contents of WWW sites on the Internet.

Synchronous

Communication in which interaction between sender and receiver takes place simultaneously (e.g. telephone or videoconferencing).

System

Set of interrelated parts, all of which together toward a defined goal.

System Architecture

A description of the design and contents of a computer system. If documented, it may include information such as a detailed inventory of current hardware, soft-

ware and networking capabilities; a description of longrange plans and priorities for future purchases, and a plan for upgrading and/or replacing dated equipment and software.

System Functions

A list of the specific capabilities a system should be able to do or staff should be able to do using the system, such as system storage and retrieval capabilities, calculation and processing capabilities, reporting and output capabilities, and telecommunications capabilities.

Task (as in "performance task")

A goal-directed assessment exercise. If the task is authentic, it is designed to elicit from students their application of a broad range of knowledge and skills to solve a complex problem.

T-1 (Line) Transport

A digital signal that transmits 1.54 megabits/second of data. This is equal to 24 telephone lines (copper). This is a stage of compressed (partial motion) video. It is used for very high quality videoconferencing.

Technical Requirements

Simple statements of parameters for a technology solution addressing topics such as the number of people who will use the system and where they are located, the numbers and types of transactions that will need to be processed, and the types of technology components that need to interact.

Technical Support Staff

Those who support and maintain the technology solution once it is implemented.

Technology

The systemic and systematic application of behaviour and physical sciences concepts and other knowledge to the solution of problems.

Technology Plan

A plan of how to get your college, school or organization from where it is now to where you want it to be.

Technology Resources

The hardware, software, networks and networking capability, staff, funding and context which together can be used in the implementation of a technology solution.

Teleconferencing

The simultaneous visual and/or sound interconnection that allows individuals in two or more locations to see and talk to one another in a long-distance conference arrangement.

Telecourses

Courses in video format that are delivered via television or videotape.

Telnet

A service that allows the user to log into a remote computer and act as a terminal on that computer. Examples include library catalogues, databases, bulletin boards, journals, and scholarly papers.

Transfer

The application of new knowledge and skills to a variety of real-life situations and future learning tasks.

Translator

A device that converts information from one system of representation into equivalent information in another system of representation. In telephone equipment, it converts dialed digits into call-routing information.

Upgrade

To install a higher version or release of software on a computer system, or to add memory or newer types of equipment to a computer system.

Uplink

The capability of sending an electronic signal to a transponder on a satellite. There are two types: K-band and C-band.

URL

Uniform Resource Locator. An address on the World Wide Web.

Users

The people who use technology as a tool to do their jobs. Typically users include instructional staff who provide instruction or do instructional management tasks

using technology, and administrative staff who use technology to do the routine and non-routine administrative activities of the organization as efficiently as possible. Students, parents, and community members can also be users. In some cases, "users" are not really users at all; they are staff who wish they had technology to use.

Utility Software

Computer programs that help to manage, recover, and back up files.

Version

A major edition of a software program. The version number changes when a software developer makes major alterations to the software such as adding new features. The version number is a whole number following the name of the software.

Videoconferencing

The ability for groups at distant locations to participate in the same meeting at the same time using analog or digital video capabilities.

Virtual Reality

A complete environment that is assembled and managed by a computer program, one in which the user enters and interacts with the program. The users wear a special interface that puts them on the playing field and makes them the players.

Vision

The ideal state or condition you would like to achieve.

WAN

Wide Area Network. A data communications linkage (e.g. dedicated line, radio waves) designed to connect computers over distances greater than the distance transmitted by local area networks (e.g. building to building, city to city, across the country, internationally) that allows users to communicate and share information, such as the Internet, America Online, etc.

Webcast

A live audio and video picture broadcast over the Internet that can be viewed and heard using a RealPlayer G2 version 5.0 (MAC) or 6.0 (PC). Version 6.0 will work on both platforms.

Web-Based Training (WBT)

A form of computer-based training in which the training material resides on pages accessible through the World Wide Web. Typical media elements used are text and graphics. Other media such as animation, audio, and video can be used, but require more bandwidth and in some cases additional software. The terms "online courses" and "web-based instruction" are sometimes used interchangeably with WBT.

Wideband

A medium capacity communications path. It has a speed of 64 Kbps to 1.544 Mbps.

Wireless

Voice, data, or video communications without the use of connecting wires. In wireless communications, radio signals make use of microwave towers or satellites. Cellular phones and pagers are examples of wireless communications.

Workstation

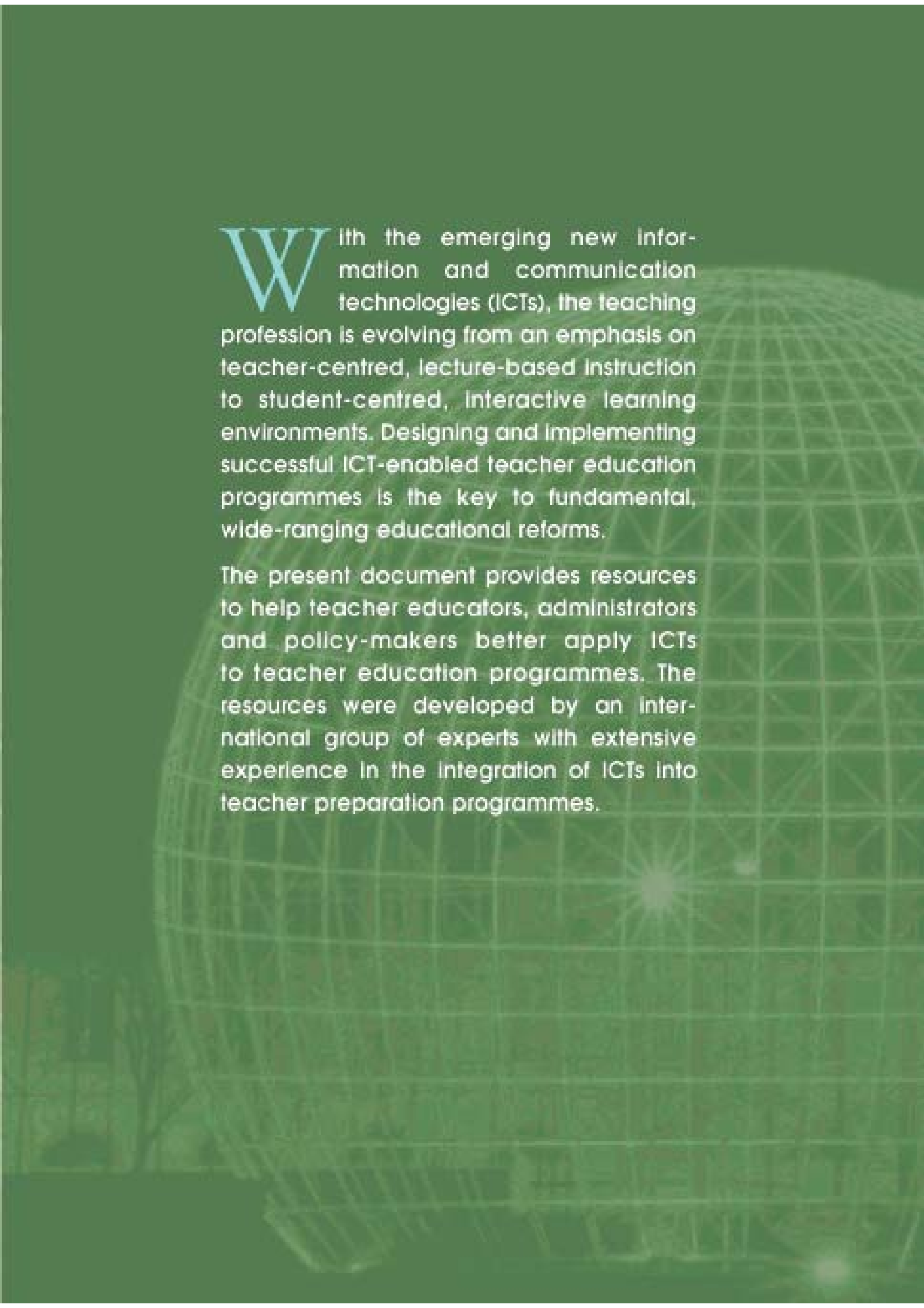
A computer that is intended for individual use but is generally more powerful than a personal computer. A workstation may also act as a terminal for a central mainframe.

WWW

World Wide Web. A system that allows access to information sites all over the world using a standard, common interface to organize and search for information. The WWW simplifies the location and retrieval of various forms of information including text, audio and video files.

Zone of Proximal Development (ZPD)

A level or range in which a student can perform a task with help.



With the emerging new information and communication technologies (ICTs), the teaching profession is evolving from an emphasis on teacher-centred, lecture-based instruction to student-centred, interactive learning environments. Designing and implementing successful ICT-enabled teacher education programmes is the key to fundamental, wide-ranging educational reforms.

The present document provides resources to help teacher educators, administrators and policy-makers better apply ICTs to teacher education programmes. The resources were developed by an international group of experts with extensive experience in the integration of ICTs into teacher preparation programmes.