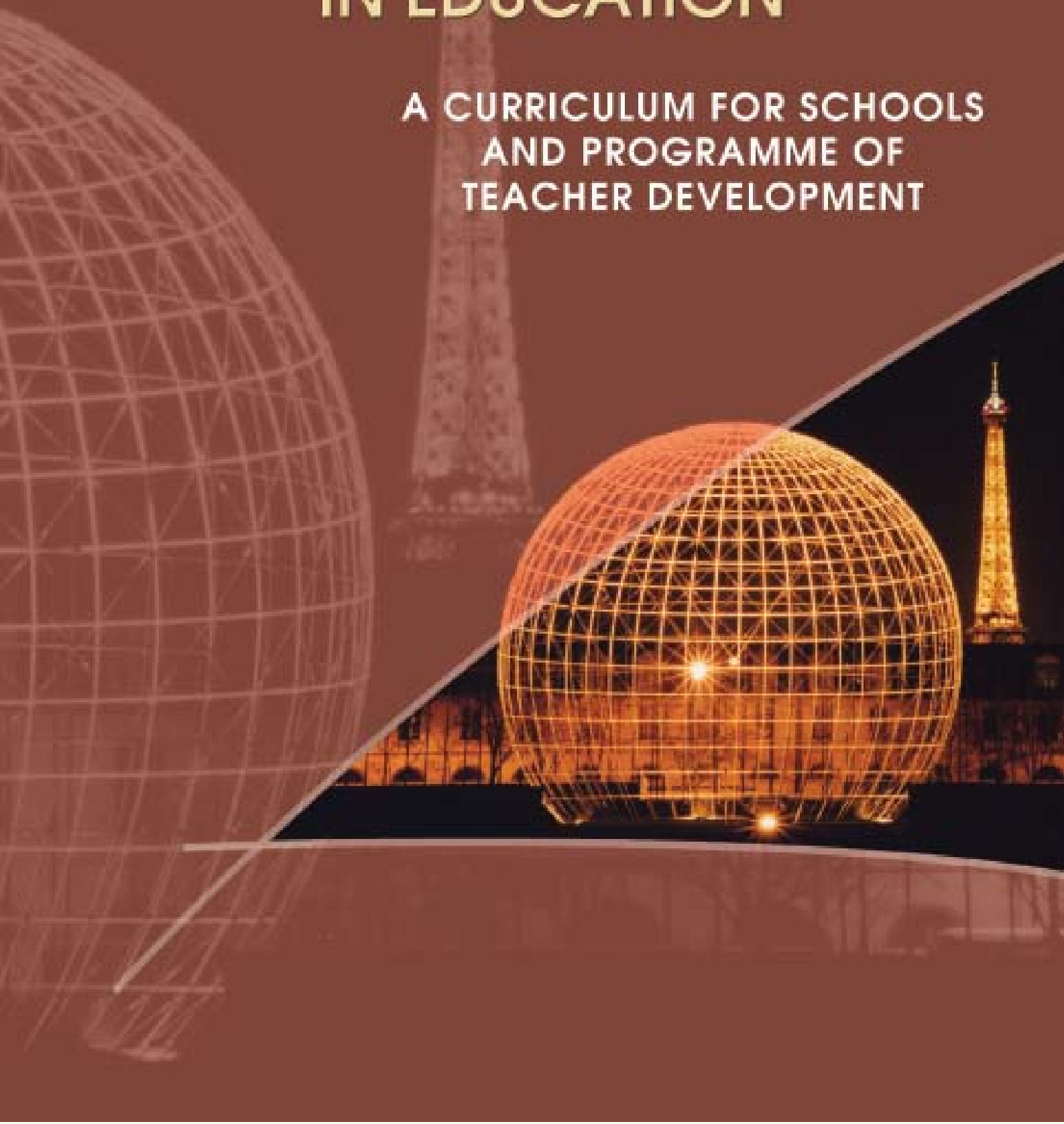
United Nations
Educational,
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Organization

INFORMATION AND COMMUNICATION TECHNOLOGY IN EDUCATION

A CURRICULUM FOR SCHOOLS AND PROGRAMME OF TEACHER DEVELOPMENT



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FOREWORD

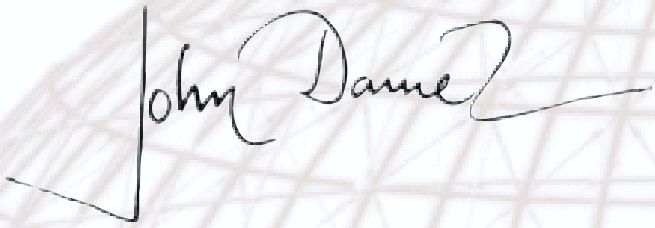
Information and communication technology (ICT) has become, within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education, alongside reading, writing and numeracy.

One of UNESCO's overriding aims is to ensure that all countries, both developed and developing, have access to the best educational facilities necessary to prepare young people to play full roles in modern society and to contribute to a knowledge nation. Maintaining a capacity to advise national governments on the use of technology in schools and, in particular, on the optimal balance, given local circumstances, between ICT and older educational technologies and assisting countries in developing educational software and materials that reflect their own national and regional cultures are key components of the Organization's strategy to achieve the *Education for All* goals.

The present publication, *Information and Communication Technology in Education: A Curriculum for Schools and Programme of Teacher Development*, is the last in a series of thematically complementary publications developed in 2002 by the Division of Higher Education and should be seen as UNESCO's contribution to assist Member States in successfully integrating the new technologies such as multimedia, e-learning and distance education delivery into their educational systems.

The book pursues two key purposes. The first is to specify a curriculum in ICT for secondary schools that is in line with current international trends. The second is to propose a programme of professional development for teachers necessary to implement the specified ICT curriculum successfully. In addition, it provides a practical and realistic approach to curriculum and teacher development that can be implemented quickly and cost effectively, according to available resources.

It gives me pleasure to acknowledge the genuine international co-operation spirit thanks to which this new publication has seen the light of day and the contribution of several internationally renowned experts from Asia, Australia, Europe and North America. A word of sincere thanks goes to the International Federation for Information Processing (IFIP) for having been the initiator of this project.



John Daniel
Assistant Director-General for Education

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I.

ICT AND EDUCATION

Information and communication technology (ICT) has become, within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education, alongside reading, writing and numeracy.

This book deals with ICT in secondary schools, and with the changing competencies required of both students and teachers if they are to function effectively in today's society. It specifies an ICT curriculum for secondary schools, and outlines an accompanying programme of teacher development to implement such a curriculum.

AIMS AND PURPOSES

UNESCO aims to ensure that all countries, both developed and developing, have access to the best educational facilities necessary to prepare young people to play full roles in modern society and to contribute to a knowledge nation. Because of the fundamental importance of ICT in the task of schools today, UNESCO has previously published books in this area as a practical means of helping Member States: for example, *Informatics for Secondary Education: A Curriculum for Schools (1994)* and *Informatics for Primary Education* (2000). Rapid developments in ICT now demand a completely new document in place of the first of these publications.

This book has two key purposes. The first is to specify a curriculum in ICT for secondary schools that is in line with current international trends. The second purpose is to outline a programme of professional development for teachers necessary to implement the specified ICT curriculum successfully.

All governments aim to provide the most comprehensive education possible for their citizens within the constraints of available finance. Because of the pivotal position of ICT in modern societies, its introduction into secondary schools will be high on any political agenda. This book gives a practical and realistic approach to curriculum and teacher development that can be implemented quickly and cost effectively, according to available resources.

The curriculum is designed to be capable of implementation throughout the world to all secondary age students. The programme of teacher professional development relates closely to the ICT curriculum, and particularly to the stage of development that schools have reached with respect to ICT.

INFORMATION AND COMMUNICATION TECHNOLOGY

ICT permeates the business environment, it underpins the success of modern corporations, and it provides governments with an efficient infrastructure. At the same time, ICT adds value to the processes of learning, and in the organization and management of learning institutions. The Internet is a driving force for much development and innovation in both developed and developing countries.

Countries must be able to benefit from technological developments. To be able to do so, a cadre of professionals has to be educated with sound ICT backgrounds, independent of specific computer platforms or software environments.

Technological developments lead to changes in work and changes in the organization of work, and required competencies are therefore changing. Gaining in importance are the following competencies:

- critical thinking,
- generalist (broad) competencies,
- ICT competencies enabling expert work,
- decision-making,
- handling of dynamic situations,
- working as a member of a team, and
- communicating effectively.

A secondary ICT curriculum should contribute to the building up of teams of professionals with these new competencies.

The use of ICT cuts across all aspects of economic and social life. Technological developments in ICT are very rapid. Technology quickly becomes obsolete requiring new skills and knowledge to be mastered frequently. Adaptation is only possible when based on a sound understanding of the principles and concepts of ICT.

CURRICULUM AND TEACHER DEVELOPMENT

Keeping pace with technological development and the changing competencies required of both students and their teachers requires a state-of-the-art curriculum and appropriate teacher development.

A state-of-the-art curriculum

The ICT curriculum for schools presented in the chapters that follow is a state-of-the-art curriculum. This curriculum offers to schools and countries where ICT curricula are evolving the foundations from which to advance rapidly. It is not effective to repeat the development process with respect to ICT education that has already taken place elsewhere since to do so only slows down development and keeps institutions and countries from closing the gap. Most important is the need to integrate or infuse ICT meaningfully throughout all school subjects. Many opportunities arise from the inclusion of ICT: the ICT curriculum presented in this book attempts to facilitate fruitful use of these opportunities.

A modular curriculum

The curriculum has been designed in modular form so that education authorities can select appropriate elements to meet their objectives at the phase of development reached in their countries. Sufficient detailed description of each objective has been given so that textbook writers and educational publishers can produce course materials that meet local, cultural, and developmental circumstances. Alternatively, high quality learning materials from developed countries may be adapted to meet local circumstances.

Professional development for teachers

Teachers need to be adequately prepared to implement a state-of-the-art ICT curriculum. Indeed, introducing any new curriculum calls for careful preparation, management, resourcing, and continuing support.

In the case of an ICT curriculum, even more concerns have to be considered. Educational research studies show that programmes of professional development for teachers are most effective if directed to the stage of ICT development reached by schools. The implications of these research findings are that teacher development is best conceived as an ongoing process, with many professional development activities conducted in schools.

VARYING CONDITIONS ACROSS COUNTRIES

Circumstances and resources vary markedly between countries, all of which will impact on the implementation of any new ICT curriculum and will affect how educational systems cope with change.

Coping with change

Rapid developments in ICT are difficult to manage for Ministries of Education, educational managers, and schools. A situation of constant change is also confronting to teaching staff and publishers. This ICT curriculum has been designed to help cope with these developments and situations of change. It helps Ministries of Education to develop a systematic and controlled secondary education ICT policy. It also helps schools to develop ICT systematically and effectively in their programmes, if need be from scratch.

Local circumstances

Circumstances vary between countries and between schools within a country, and implementation factors have therefore to be taken into account when designing ICT curricula. The ICT curriculum presented here offers to countries and schools a development framework that takes account of these variations between countries and schools.

Various curriculum realizations, each of which is strongly influenced by cultural, societal and institutional factors, can be constructed in a straight forward way from the ICT curriculum that is presented. Schools and countries will be able to construct an up-to-date curriculum from the curriculum framework provided in a process in which specific needs, restrictions with respect to resources, and other local circumstances are taken into account. The curriculum allows educational publishers and textbook writers to produce learning materials in the cultural traditions of their country.

Availability of resources

In any educational system, the level of available resources places a restriction on the degree to which any new subject can be introduced into the school curriculum, especially where only the most basic facilities have so far been provided. But ICT is of such importance to the future industrial and commercial health of a country that investment in the equipment, teacher education, and support services necessary for the effective delivery of an ICT-based curriculum should rank high in any set of government priorities.

The curriculum proposed takes account of these resource issues and specifies minimum requirements for effective delivery in different circumstances.

TERMINOLOGY

To define information and communication technology (ICT), a term used in the title of this book and extensively throughout, two other terms need first to be defined.

Informatics (Computing Science)

UNESCO defines informatics as the science dealing with the design, realization, evaluation, use, and maintenance of information processing systems, including hardware, software, organizational and human aspects, and the industrial, commercial, governmental and political implications of these.

Informatics technology

Informatics technology is defined as the technological applications (artifacts) of informatics in society.

Information and communication technology (ICT)

Information and communication technology, or ICT, is defined as the combination of informatics technology with other, related technologies, specifically communication technology.

In this book, these three definitions have been collapsed into a single, all encompassing, definition of ICT. This definition implies that ICT will be used, applied, and integrated in activities of working and learning on the basis of conceptual understanding and methods of informatics.

II.

MODELLING ICT DEVELOPMENT

In developing a curriculum for ICT, it is useful to have a model for ICT development. Such a model is not a miniature replica of some three-dimensional object but rather a representation of the essential characteristics of ICT development to provide a scaffold or framework. Such a framework shows the interrelationship of various components within a system and aids understanding by educational administrators and policy-makers.

Two models are presented here to provide a framework for what follows. The first model conceives ICT development as a continuum along which an educational system or an individual school can pinpoint the approach that relates to the growth of ICT for their particular context. This model is referred to as *a continuum of approaches to ICT development.*

The second model depicts different stages in the way that those who are most involved in the use of ICT in schools – teachers and students – discover, learn about, understand, and specialize in the use of ICT tools. This second model is referred to as *stages of teaching and learning with and through ICT.*

The two models, *a continuum of approaches to ICT development* and *stages of teaching and learning with and through ICT*, together provide the framework for an ICT curriculum and for the professional development of teachers detailed in this book.

A CONTINUUM OF APPROACHES

Studies of ICT development in both developed and developing countries identify at least four broad approaches through which educational systems and individual schools proceed in their adoption and use of ICT. These four approaches, termed *emerging*, *applying*, *infusing*, and *transforming*, represent a continuum depicted as the model in Figure 2.1.



Figure 2.1. Model depicting a continuum of approaches to ICT development in schools

The emerging approach

Schools at the beginning stages of ICT development demonstrate the emerging approach. Such schools begin to purchase, or have had donated, some computing equipment and software. In this initial phase, administrators and teachers are just starting to explore the possibilities and consequences of using ICT for school management and adding ICT to the curriculum.

Schools at this emerging phase are still firmly grounded in traditional, teacher-centred practice. The curriculum reflects an increase in basic skills but there is an awareness of the uses of ICT. This curriculum assists movement to the next approach if so desired.

The applying approach

Those schools in which a new understanding of the contribution of ICT to learning has developed exemplify the applying approach. In this secondary phase, administrators and teachers use ICT for tasks already carried out in school management and in the curriculum. Teachers largely dominate the learning environment.

Schools at the applying approach phase adapt the curriculum in order to increase the use of ICT in various subject areas with specific tools and software. This curriculum assists movement to the next approach if so desired.

The infusing approach

At the next stage, the infusing approach involves integrating or embedding ICT across the curriculum, and is seen in those schools that now employ a range of computer-based technologies in laboratories, classrooms, and administrative offices. Teachers explore new ways in which ICT changes their personal productivity and professional practice. The curriculum begins to merge subject areas to reflect real-world applications.

The transforming approach

Schools that use ICT to rethink and renew school organization in creative ways are at the transforming approach. ICT becomes an integral though invisible part of daily personal productivity and professional practice. The focus of the curriculum is now learner-centred and integrates subject areas in real-world applications. ICT is taught as a separate subject at the professional level and is incorporated into all vocational areas. Schools have become centres of learning for their communities.

STAGES OF TEACHING AND LEARNING

Teaching and learning are best thought of, not as separate and independent activities, but rather as two sides of the same coin, interconnected and interrelated. Studies of teaching and learning in schools around the world identify four broad stages in the way that teachers and students learn about and gain confidence in the use of ICT. These four stages give rise to the model depicted in Figure 2.2 that shows the stages in terms of discovering, learning how, understanding how and when, and specializing in the use of ICT tools.

Discovering ICT tools

The first stage (Stage A in Figure 2.2) that teachers and learners go through in ICT development is of discovering ICT tools and their general functions and uses. In this discovery stage, there is usually an emphasis on ICT literacy and basic skills. This stage of discovering ICT tools is linked with the emerging approach in ICT development.

Learning how to use ICT tools

Following on from the discovery of ICT tools comes the stage of learning how to use ICT tools, and beginning to make use of them in different disciplines (Stage B in Figure 2.2). This stage involves the use of general or particular applications of ICT, and is linked with the *applying approach* in ICT development.

Understanding how and when to use ICT tools

The next stage (Stage C in Figure 2.2) is understanding how and when to use ICT tools to achieve a particular purpose, such as in completing a given project. This stage implies the ability to recognize situations where ICT will be helpful, choosing the most appropriate tools for a particular task, and using these tools in combination to solve real problems. This stage is linked with the *infusing* and *transforming approaches* in ICT development.

Specializing in the use of ICT tools

The fourth and last stage (Stage D in Figure 2.2) involves specializing in the use of ICT tools such as occurs when one enters more deeply into the science that creates and supports ICT. In this stage students study ICT as a subject to become specialists. Such study concerns vocational or professional education rather than general education and is quite different from previous stages involving the use of ICT tools.

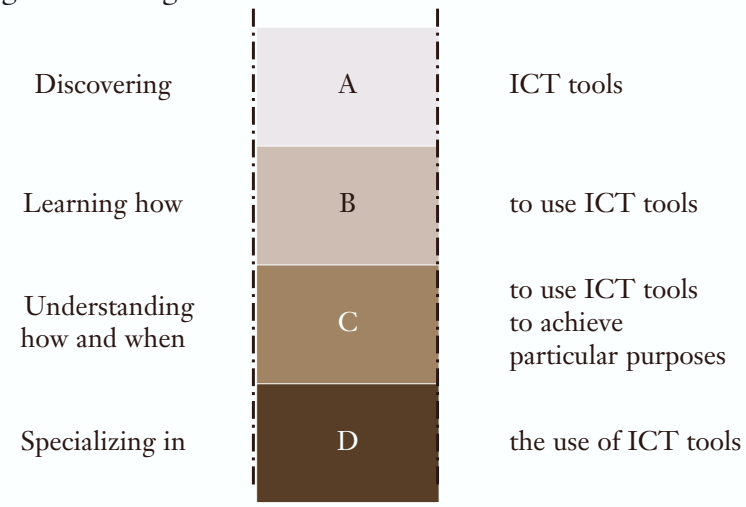


Figure 2.2 Model of stages of teaching and learning with and through ICT

A CURRICULUM STRUCTURE FOR SECONDARY SCHOOLS

The model depicted in Figure 2.2 is useful in developing the structure of a curriculum designed for both teachers and students to improve their knowledge and skills in ICT. The design supplies four curriculum areas tied to the four stages of teaching and learning, allowing schools to progress from:

- *ICT Literacy* (where ICT skills are taught and learned as a separate subject) to
- *Application of ICT in Subject Areas* (where ICT skills are developed within separate subjects) to
- *Infusing ICT across the Curriculum* (where ICT is integrated or em-bedded across all subjects of the curriculum) to
- *ICT Specialization* (where ICT is taught and learned as an applied subject or to prepare for a profession).

In Chapter IV, specific modules and examples of projects are presented for each of the four curriculum areas noted, further details of which follow.

ICT literacy

This curriculum area covers the use of ICT as encountered in the daily life of many communities. Specific units include basic concepts of ICT, using computers and managing files, word processing, spreadsheets, databases, creating presentations, finding information and communicating with computers, social and ethical issues, and jobs using ICT. *The International Computer Driving Licence*, which derived from *The European Computer Driving Licence* (see General References), was helpful in the organization of this area of the curriculum.

Application of ICT in subject areas

This area of the curriculum covers the application of ICT tools for working within specific subject areas such as languages, natural sciences, mathematics, social sciences, and art. Specific units include measurement, modelling and simulation, robots and feedback devices, statistics, creating graphics, spreadsheet design, and database design.

Infusing ICT across the curriculum

Examples of projects included in this area of the curriculum demonstrate the use of ICT across subject areas to work on real-world projects and to solve real problems. Some examples show how, within a particular course, ICT can help students integrate several subject areas, such as mathematics, science, and art. Other examples show larger projects that cut across several subject areas or illustrate how a number of schools can integrate ICT in community or global projects.

ICT specialization

This area of the curriculum is designed for students who plan to go into professions that use ICT such as, for example, engineering, business, and computer science, or for students who plan to advance to higher education. Content covers the use of advanced tools and techniques for the ICT specialist. Specific units include basic and advancing programming, planning information systems, designing process control systems, and project management.

PROFESSIONAL DEVELOPMENT OF TEACHERS

In the same way that a model proves useful in developing a curriculum structure for schools, the model is similarly useful in planning for the professional development of teachers, which is so essential in the professional life of teachers when they begin to use ICT. The model depicted in Figure 2.1 that identifies approaches to ICT development helps provide a framework for professional development of staff in schools.

Emerging ICT skills and knowledge

In the emerging approach to ICT development, the focus is on the technical functions and uses of ICT and on the need for some knowledge and representation of the impacts of ICT systems as a whole. This approach often involves teachers' personal use of ICT, such as, for instance, the use of word processing to prepare worksheets, locating information on CD-ROMs or on the Internet, or communicating with friends and family by email. Here, teachers are developing their ICT literacy and learning how to apply ICT to a range of personal and professional tasks. The emphasis is on training in a range of tools and applications, and increasing teachers' awareness of the opportunities for applying ICT to their teaching in the future.

Applying ICT to teachers' subject areas

In the applying approach, teachers use ICT for professional purposes, focusing on improving their subject teaching in order to enrich how they teach with a range of ICT applications. This approach often involves teachers in integrating ICT to teach specific subject skills and knowledge; beginning to change their methodology in the classroom; and using ICT to support their training and professional development.

Teachers gain confidence in a number of generic and specialized ICT tools that can be applied to the teaching of their subject area. The opportunity to apply ICT in all their teaching is often limited only by a lack of ready access to ICT facilities and resources, which is why it is not fully integrated into all lessons for all students.

Infusing ICT to improve learning and management of learning

In the infusing approach to ICT development, ICT infuses all aspects of teachers' professional lives in such ways as to improve student learning and the management of learning processes. The approach supports active and creative teachers who are able to stimulate and manage the learning of students, integrating a range of preferred learning styles and uses of ICT in achieving their goals. The infusing approach often involves teachers easily integrating different knowledge and skills from other subjects into project-based curricula.

In this approach, teachers fully integrate ICT in all aspects of their professional lives to improve their own learning and the learning of their students. They use ICT to manage not only the learning of their students but also their own learning. They use ICT to assist all students to assess their own learning in achieving specific personal projects. In this approach, it becomes quite natural to collaborate with other teachers in solving common problems and to share their teaching experiences with others.

Transforming teaching through ICT

In the transforming approach to ICT development, teachers and other school staff regard ICT as so natural and part of the everyday life of schools that they begin to look at the process of teaching and learning in new ways. The emphasis changes from teacher-centred to learning-centred. Teachers, together with their students, expect a continuously changing teaching methodology designed to meet individual learning objectives.

III.

ICT DEVELOPMENT AT THE SCHOOL LEVEL

The previous chapter identifies various approaches to the development of ICT in secondary education. This chapter first describes these approaches, which fall along a continuum, in further detail. Next, are detailed various characteristics associated with schools and school leadership such as vision, facilities and resources, community involvement, and so on, that relate to ICT development in schools. Finally, a two-dimensional matrix is developed with approaches to ICT development along one dimension, and characteristics of schools relating to ICT development along the other dimension. This matrix should prove useful to schools as an aid in determining their stage of development with regard to ICT development.

APPROACHES TO ICT DEVELOPMENT

Advances in technology and the way technology is incorporated into a system is a dynamic process. Each school must work within the context of its own system to fit choices to what best suits its unique situation and culture. Even within a school, various units or courses may use different approaches. The approaches are hierarchical with the emerging approach as a beginning point, and the transforming approach as a goal many perceive as the future of education.

Emerging

The emerging approach is linked with schools at the beginning stages of ICT development. Such schools begin to purchase computer equipment and software or perhaps have had some donated. In this initial phase, administrators and teachers are just starting to explore the possibilities and consequences of

adding ICT for school management and the curriculum. The school is still firmly grounded in traditional, teacher-centred practice. For example, teachers tend to lecture and provide content while students listen, take notes, and are assessed on the prescribed content. School organization provides discrete time periods for each subject. Learners' access to technology is through individual teachers. A curriculum that focuses on basic skills and an awareness of the uses of ICT assists movement to the next approach.

Applying

The applying approach is linked with schools in which a new understanding of the contribution of ICT to learning has developed. In this phase, administrators and teachers use ICT for tasks already carried out in school management and in the curriculum. Teachers still largely dominate the learning environment. For example, instructing may be supplemented with ICT such as electronic slide presentations and word-processed handouts. Students receive instruction and add notes to teacher prepared handouts. They use ICT tools to complete required lessons and are assessed on prescribed content. School organization provides discrete time periods for each subject with some flexibility to combine subjects and time periods. Learner access to technology is through one or two classroom computers and computer labs. Until now, ICT has been taught as a separate subject area. To move to the next phase, the school chooses to implement an ICT-based curriculum that increases ICT across various subject areas with the use of specific tools and software.

Infusing

The infusing approach is linked with schools that now have a range of computer-based technologies in laboratories, classrooms, and administrative areas. Teachers explore new ways in which ICT changes their personal productivity and professional practice. The curriculum begins to merge subject areas to reflect real-world applications. For example, content is provided from multiple sources, including community and global resources through the World Wide Web. Students' access to technology enables them to choose projects and ICT tools that stimulate learning and demonstrate their knowledge across subject areas. School organization provides the flexibility to combine subjects and time periods. Learners have more choices with regard to learning styles and pathways. They take more responsibility for their own learning and assessment. ICT is taught to selected students as a subject area at the professional level. To

advance to the next phase, schools choose an ICT curriculum that allows a project-based, ICT-enhanced approach. These schools begin to involve the community more in the learning environment and as resource providers.

Transforming

The transforming approach is linked with schools that have used ICT creatively to rethink and renew school organization. ICT becomes an integral though invisible part of the daily personal productivity and professional practice. The focus of the curriculum is now much more learner-centred and integrates subject areas in real-world applications. For example, students may work with community leaders to solve local problems by accessing, analyzing, reporting, and presenting information with ICT tools. Learners' access to technology is broad and unrestricted. They take even more responsibility for their own learning and assessment. ICT is taught as a subject area at an applied level and is incorporated into all vocational areas. The school has become a centre of learning for the community.

CHARACTERISTICS OF SCHOOLS RELATED TO ICT DEVELOPMENT

Along with approaches to ICT development noted above, there are various characteristics of schools, or aspects of school leadership, that relate to a school's progress in ICT development. Below are general descriptions of the more important of these characteristics of schools that have an effect on ICT development within schools.

Vision

Vision refers to the aspirations and goals of both individuals within a school and the school system as a whole. As the school advances, the mission statements should become clearer and provide a basis for decision-making. Mission statements should help individual members of the learning community visualize a school's aspirations for the future and act in harmony.

Philosophy of learning and pedagogy

Ways in which teachers and students interact and how the school is managed for learning are part of what is meant by a school's philosophy of learning and

pedagogy. These philosophies will necessarily characterize the ways in which ICT is incorporated into a school. A setting that is dominated by the teacher as the main provider of subject content is adopting a teacher-centred philosophy. The teacher controls the use of ICT in such a setting as well. A learner-centred philosophy, by contrast, describes a setting where content comes from a variety of resources, and where projects are chosen and designed by the students. ICT tools and resources are selected by students in ways that match the aims of a project best. These contrasting approaches to pedagogy are sometimes referred to as instructivist and constructivist respectively.

Development plans and policies

How a school's vision and teaching philosophies are carried out is translated into development plans and policies. In the detailed steps of such plans and policies, goals and objectives are further defined providing interim and long-term targets. Policies are set, a budget is allocated, facilities are determined, roles are defined, tasks are delegated, and an evaluation plan is created to define the direction ICT development will take.

Facilities and resources

The learning environment in which ICT is used requires certain facilities and resources. Facilities include basic infrastructure such as electrical wiring, Internet access, lighting, air-conditioning, and space. Decisions on inclusion or lack of ergonomic design and choice of furniture impact not only on use of ICT, but also on the health and well being of users. Resources include various types of technological devices from computers with peripherals, video equipment, and specialized tools like digital microscopes. Further resources include various types of software, as well as traditional tools like books, videos, and audiotapes.

Understanding the curriculum

An understanding of the curriculum affects the progression of ICT in the curriculum in following various stages of development. First, is an awareness stage in which students become ICT literate with regard to what technology is available and how it might be used. Second, as students learn basic skills, they begin to apply various ICT tools to their regular learning assignments and projects. Third, as students become more capable and confident with ICT, they begin to integrate and overlap both subject areas and tools. Last, is the applied use of ICT in which students are now enabled to address larger, more complex, real-world professional issues.

Professional development of school staff

In parallel with the curriculum for students, there must be professional development of the staff within a school. The personal productivity and professional practice of teachers are enhanced with the use of ICT. First, is an awareness stage in which teachers and staff become ICT literate with regard to what technology is available and how it might be used. Second, as teachers and staff learn basic skills, they begin to apply various ICT tools to their regular tasks and projects. Third, as teachers and staff become more capable and confident with ICT, they begin to integrate and overlap both subject areas and tools. Last, is a change in professional practice in which teachers are now enabled to design lessons to incorporate larger, more complex, real-world projects using ICT tools and resources. As ICT is introduced into school systems, there is a tendency to move from discrete skills training to reflective practice and integrative professional development. Budgetary allocation and provision for release time for teacher professional development seriously impact on the ability of a school system to incorporate ICT in a meaningful way.

Community involvement

Community involvement may include parents, families, businesses, industry, government agencies, private foundations, social, religious and professional organizations, as well as other educational institutions such as vocational schools and universities. Community involvement can come in the form of donations of equipment and resources, or may be in human resources provided for training and technical assistance. As a community contributes to a school, so the school can give back in many ways. For example, a school may decide to provide community members with evening access to computer labs, or have students offer training to parents. The use of ICT provides an opportunity for a school and its students to interact with both local and global communities. Interaction may range from building web sites for community organizations, to sharing projects with remote schools.

Assessment

Assessment includes both assessments of students as well as overall evaluation of a school system, two aspects that are intricately interwoven. An improvement in the one should predicate an improvement in the other. Means of student assessment should reflect choices in learning pedagogy and an understanding of ICT in the curriculum. For example, in the emerging and applying stages of ICT, assessment may be linked to pencil

and paper tests, whereas in the infusing and transforming stages project-based portfolios may be more appropriate. Each part of a school system needs to be evaluated to determine its impact on learning. Assessment should inform practice and support the management of learning. Assessment should allow a system to determine whether outcomes have been met, and then reviewed and revised accordingly. Budget allocations, policies, and procedures for ICT should match vision, teaching philosophies, and curriculum choices.

A MATRIX FOR ICT DEVELOPMENT IN SCHOOLS

A two-dimensional matrix is developed below (see Table 3.1) that helps schools determine their stage of progress with regard to the implementation of ICT in the curriculum. Along the horizontal dimension are charted the four approaches to ICT development described first in this chapter, while along the vertical dimension are the eight characteristics of schools that relate to ICT development described immediately above in this chapter. Each cell of the matrix provides a brief picture or set of indicators of how a particular approach to ICT may look like in schools sharing similar characteristics. For each row of the matrix, a school may find itself more in one cell while being less involved in other cells. Both the identified approaches and the characteristics of schools depicted in Table 3.1 derive from international trends in the use of ICT in education.

Emerging approach

The second column of Table 3.1 lists indicators for eight characteristics of schools under the emerging approach to ICT development. These indicators are now described in more detail.

Vision

The school's vision of learning and ICT is beginning to develop. The use of ICT is focused on computers under the responsibility of an enthusiastic individual or a small group with very specific uses for teaching or administration, based on their own knowledge and expertise. The vision is a pragmatic response with access to resources and expertise available.

Philosophy of learning and pedagogy

The individual teacher is responsible for discrete lessons concentrating on the development of ICT skills and the transmission of subject knowledge. The pedagogy of the enthusiastic individual or small group of teachers is restricted by the school organization and fixed timetable lesson periods.

Development plans and policies

The development of ICT in the school is separate from the overall school development plan and policies regarding curriculum, personnel, professional development, finance, community, teaching, learning and assessment. Teachers and students discover for themselves opportunities to use computers and software.

Facilities and resources

The ICT facilities and resources consist of a few isolated, stand-alone computers and printers in the school office and a few classrooms. The content available is very limited consisting of generic office type applications and school management software, with a few games providing reward to some pupils. Content will be determined by the needs of a few teachers and their teaching.

Understanding the curriculum

ICT teaching is to ensure students are ICT literate. The curriculum is structured to teach students a sound basic understanding of available software applications. The curriculum is planned and delivered by individual teachers.

Professional development of school staff

Learning and ICT training will emphasize the need to learn to operate a limited range of software for teaching and administration. Individual members of staff will identify their training needs, which is generally restricted to technical training. The ICT development plan will identify training separately from other school training and professional development. ICT training and development is partly funded by the school and teachers.

Table 3.1. Matrix of indicators to determine a school's stage of progress in implementing ICT in terms of four approaches to ICT development and eight characteristics of schools

	Emerging	Applying
Vision	Dominated by individual interest. Limited. Pragmatic.	Driven by ICT specialists.
Learning pedagogy	Teacher-centred. Didactic.	Factual knowledge-based learning. Teacher-centred. Didactic. ICT a separate subject.
Development plans and policies	Non-existent. Accidental. Restrictive policies. No planned funding.	Limited. ICT development led by specialist. Centralized policies. Hardware and software funding. Automating existing practices.
Facilities and resources	Stand-alone workstations for administration. Individual classrooms. Computers and printers. Word processing, spreadsheets, databases, presentation software. School administration software. Games.	Computer lab or individual classrooms for ICT specific outcomes. Computers, printers and limited peripherals. Word processing, spreadsheets, databases, presentation software. ICT software. Internet access.
Understanding of curriculum	ICT literacy. Awareness of software. Responsibility of individual teachers.	Applying software within discrete subjects. Use of artificial and isolated contexts.
Professional development for school staff	Individual interest.	ICT applications training. Unplanned. Personal ICT skills.
Community	Discreet donations. Problem-driven. Accidental.	Seeking donations and grants. Parental and community involvement in ICT.
Assessment	Equipment-based. Budget-oriented. Discrete subjects. Didactic. Paper and pencil. Controlling. Closed tasks. Responsibility of individual teacher.	Skills-based. Teacher-centred. Subject focused. Reporting levels. Moderated within subject areas.

Infusing	Transforming
Driven by subject specialists. Discrete areas.	Leadership. Acceptance by entire learning community. Network-centred community.
Learner-centred learning. Collaborative.	Critical thinking and informed decision-making. Whole learner, multi-sensory, preferred learning styles. Collaborative. Experiential.
Individual subject plans include ICT. Permissive policies. Broadly-based funding, including teacher professional development.	ICT is integral to overall school development plan. All students and all teachers involved. Inclusive policies. All aspects of ICT funding integral to overall school budget. Integral professional development.
Computer lab and/or classroom computers. Networked classrooms. Intranet and Internet. Resource-rich learning centres. Range of devices, including digital cameras, scanners, video and audio recorders, graphical calculators, portable computers, remote sensing devices. Video-conferencing. Word processing, spreadsheets databases, presentation software. Range of subject-oriented content. Multimedia authoring, video/ audio production. Range of subject specific software.	Whole school learning with ICT with access to technology resources and a wide range of current devices. Emphasis on a diverse set of learning environments. The whole range of devices in the column to the left and web-based learning spaces. Brainstorming. Conferencing and collaboration. Distance education. Web courseware. Student self-management software.
Infusion with non-ICT content. Integrated learning systems. Authentic contexts. Problem solving project methodology. Resources-based learning.	Virtual and real-time contexts, new world modelling. ICT is accepted as a pedagogical agent itself. The curriculum is delivered via the Web and staff in an integrated way.
Subject specific. Professional skills. Integrating subject areas using ICT. Evolving.	Focus on learning and management of learning. Self-managed, personal vision and plan, school supported. Innovative and creative. Integrated learning community with students and teachers as co-learners.
Subject-based learning community providing discrete, occasional assistance, by request. Global and local networked communities.	Broad-based learning community actively involved parents and families, business, industry, religious organizations, universities, vocational schools, voluntary organizations. Global and local, real and virtual. School is a learning resource for the community – physically and virtually.
Integrated. Portfolios. Subject-oriented. Learner-centred. Student responsibility Multiple media to demonstrate attainment. Moderated across subject areas. Social and ethical as well as technical.	Continuous. Holistic – the whole learner. Peer-mediated. Learner -centred. Learning community involvement. Open-ended. Project-based.

Community

Community involvement in the school is a welcome, although often an un-planned activity. There may be contribution by community members to school activities and the school becomes a focus of the community.

Assessment

Assessment strategies emphasize the limiting nature of equipment and budget on levels of attainment. Paper and pencil testing is widely used due to the limited ICT resources. Assessment allows the teacher to control the pace of learning. Assessment tasks and moderation of levels of attainment is the responsibility of the individual teacher. ICT assessment is independent of other student and school assessments.

Applying approach

Indicators for the eight characteristics of schools under the applying approach to ICT development listed in the third column of Table 3.1 are described in more detail below.

Vision

The school ICT specialist is responsible for any statement about a vision of learning and ICT in the school. There is an emphasis on learning about ICT and developing the school's facilities and resources.

Philosophy of learning and pedagogy

A teacher-centred didactic approach focuses on development and transmission of ICT skills and factual knowledge. The pedagogy of the school ICT specialist drives the teaching and use of ICT as a separate, specialist subject.

Development plans and policies

Responsibility for development of an ICT plan and policies is delegated to the ICT specialist in the school. Emphazis is placed on acquiring computer equipment and resources but plans and policies centralize the use and access to ICT resources, tightly managing access opportunities. Funding is provided for the acquisition of hardware and software in support for a defined

part of the school's curriculum and pedagogy. The school plan seeks to increase teaching and administration efficiency and effectiveness.

Facilities and resources

The school ICT specialist manages all available ICT resources, such as any computer laboratories in the school and stand-alone computers in classrooms, together with access to these. There is a limited range of computer peripherals such as printers with usage specific to the ICT curriculum. Internet access is available for some of the computers in the school. Software is available to teach the ICT curriculum. The applications are used within teaching contexts created by individual teachers to provide clear and predictable results for students, ensuring success. The Internet and the World Wide Web are used in a customized way with planned access to selected sites to ensure predictable outcomes to lessons.

Understanding the curriculum

ICT teaching will provide opportunities for students to apply their ICT literacy skills using teacher-created examples within specified contexts. The curriculum is structured to provide students with opportunities to apply their ICT literacy in other subject areas to acquire specific skills and knowledge.

Professional development of school staff

Skills training will be provided to support teachers of the ICT curriculum. The training will support the use of individual software applications and learning resources. Training will concentrate on the management of ICT, emphasizing personal ICT skill development. Training will tend to be "just-in-time" for a specific teaching topic or to coincide with the arrival of a new piece of software. Internet-based training will emphasize the identification of information, with direct support for the existing curriculum in a range of subjects.

Community

The school ICT specialist will seek donations and grants to develop the ICT resources and facilities within the school. ICT skills of parents and community members will be sought in support of the specified curriculum.

Assessment

Assessment allows teachers to report students' level of ICT literacy and their ability to apply what they have learned in ICT and other subjects. Individual teachers share assessments of students' attainment with other teachers within their subject area to moderate their reporting of standards of attainment. The assessments provide the opportunity for teachers to amend their curriculum. Assessment strategies are the responsibility of individual subject areas.

Infusing approach

Further detail about the indicators for each of the eight characteristics of schools under the infusing approach to ICT development listed in the fourth column of Table 3.1 follow.

Vision

The school's learning and vision for ICT is developed and shared by subject specialists who seek to increase student levels of attainment in their subjects, exploring new ways of learning and the management of learning. The vision belongs to all staff and to the school's local and global learning communities, as well as to students.

Philosophy of learning and pedagogy

A learner-centred approach, supporting students' choice of preferred learning styles and learning environments, tends to dominate. Students are able to collaborate with other learners, infusing learning across subjects, and utilizing a wide range of resources found by students. The use of ICT to investigate and explore new approaches to learning is accepted.

Development plans and policies

The individual subject areas infuse ICT into their plans and policies within the total school development plan and policies. The school's planning processes encourage collaborative approaches to learning and the management of learning by staff and students. Funding of ICT is broadly-based and integral to the annual budgetary cycle. The provision of funding covers all aspects of ICT, including professional development of school staff.

Facilities and resources

The whole school is networked to ensure access to multimedia and learning-rich resources via the school's Intranet and the Internet wherever students and teachers are, in or out of school. The computer labs and classroom computers are sufficient in number to allow ready access by students and staff in most subjects across the school. Software content is critically appraised to ensure it matches the requirements of the curriculum supporting a wide range of multi-sensory learning styles. All staff help identify the software and learning resources required. A wide range of peripheral and remote working devices, including video-conferencing, is provided and integrated into the curriculum. Large and small group presentation facilities are readily available.

Understanding the curriculum

The curriculum provides the opportunity for students to utilize their ICT literacy skills in real problem solving by means of project work that offers new ways for students to demonstrate their learning. The curriculum seeks to use real contexts for learning, using school-based and externally available resources. ICT is used as a tutor to support specific learning goals. Teachers regularly review the curriculum for opportunities to incorporate the use of ICT.

Professional development of school staff

Emphazis is placed on the professional development of teachers' subject skills and their capabilities to apply ICT in a range of contexts. The provision of school-based, in-service training to support the shared development of collaborative, cross-curriculum uses of ICT complements any external professional development provision. The school's programme of professional development has evolved to meet changing needs and new opportunities.

Community

Staff and students make ready use of their local and emerging global learning communities to provide specific assistance for additional opportunities offered through ICT, especially the Internet and video-conferencing. The school has a regular programme to attract donations and grants to further develop ICT resources and curriculum within the school.

Assessment

Students' assessments are not limited to specific subjects, with reports on attainment informing all teachers in planning teaching and learning programmes of study. Students are responsible for maintaining personal portfolios of their work, demonstrating their attainment, over one or more years, using ICT facilities and resources to complement paper-based records. The assessments inform whole school curriculum planning and resource allocations.

Transforming approach

The final column in Table 3.1 lists indicators for the eight characteristics of schools under the transforming approach. These indicators are described in further detail below.

Vision

The school provides leadership to its learning community, providing innovative and creative access and opportunities to learning and the management of learning, maximizing the contribution of ICT to realize the school of tomorrow, today. The school sees itself as network-centred, providing a physical place to learn, as well as web-based learning spaces, accessible any time, anywhere, by students and staff.

Philosophy of learning and pedagogy

Emphazis is upon the whole learner in all aspects of their learning, with a focus on critical thinking skills and well-founded decision-making. Every student is responsible for his or her own learning. Learning is experiential, with learning pathways and learning styles continuously changing to meet learner requirements. The use of ICT to investigate and explore new approaches to learning is expected.

Development plans and policies

The school and learning community use ICT to rethink creatively and to renew the learning environment of students and staff, including the development planning and policy-making processes. The plans for the

school seek to support continuous change and renewal, striving to provide truly differentiated and individualized curriculum for all students, and seeking to maximize student achievement. ICT funding is seen as essential as funding for basic utilities like water and power. Effective, accessible, and inclusive ICT ensures that learning environments are mission-critical to all staff, students and learning communities.

Facilities and resources

A whole school learning and ICT infrastructure provides ready access to innovative learning environments and contexts. School facilities and resources are designed and enabled to support continuous change and development of approaches to learning, the management of learning, and technology.

Understanding the curriculum

The curriculum is enabled by an understanding of the learning needs of every student, informed on a continuous basis by management of learning systems. Students' ICT literacy skills are assumed to enable learning readily within a personalized curriculum. The curriculum uses as a matter of course virtual and real world, real-time contexts, and modelling. Students are involved in solving real problems.

Professional development of school staff

Focus is placed on learning and the management of learning, with specific ICT training provided when it is required. Teachers' development is self-managed, and informed by a well-founded personal vision and plan, that supports the school's overall vision and the needs of the learners. Teachers accept their role as co-learners, learning together with their students. Teachers are committed to professional development as a continuous, critically reflective process.

Community

The community is a natural partner with the school, actively involved in all aspects of the staff and students' learning processes, and providing

real-world contexts through which learning takes place. In turn, the school is a learning resource for the whole community, offering access to local and global learning environments with physical visits as well as virtual visits through the Internet. The school is as much a part of the community as the community is a part of the school: the boundaries are indistinct to the observer.

Assessment

Students are responsible for their own continuous assessment to inform and plan a personal curriculum that is matched to their preferred learning styles. The assessments are moderated between students as well as between teachers, providing a holistic view of the whole learner across the curriculum. Students maintain a portfolio of all their work on the network. Students' attainments and preferred learning styles determine the school's curriculum and policies. Staff and student assessments determine the management of learning.

IV.

ICT CURRICULUM FOR SECONDARY STUDENTS

In Chapter II, a model is presented (see Figure 2.2), from which evolved a curriculum framework containing four broad curriculum areas to serve as a means for both teachers and students to improve their knowledge and skills in ICT. The focus in this chapter is on developing an ICT curriculum for students at the secondary level, while the next chapter takes up the question of the professional development of teachers.

The four broad curriculum areas arising from Figure 2.2 and described in Chapter II translate into the four curriculum modules shown in Table 4.1: *ICT Literacy*, *Application of ICT in Subject Areas*, *Infusing ICT across the Curriculum*, and *ICT Specialization*. Table 4.1 provides a convenient overview of the total ICT curriculum for students in secondary schools.

The four curriculum modules shown in Table 4.1, together with the units that comprise each module, are described below, with further elaboration in Appendices A, B, C, and D respectively.

ICT LITERACY

The module, *ICT Literacy*, is the first stage of the curriculum. This first module is designed for students to discover ICT tools and their general functions and uses. The module comprises nine units:

A1 Basic Concepts of ICT
A2 Using the Computer and Managing Files
A3 Word Processing
A4 Working with a Spreadsheet
A5 Working with a Database
A6 Composing Documents and Presentations
A7 Information and Communication
A8 Social and Ethical Issues
A9 Jobs and/with ICT

The nine units comprising the *ICT Literacy* module are designated A1 through A9, where A denotes the first stage or Stage A. The first unit (A1 Basic Concepts of ICT) can be taught as a separate unit, or it may be integrated within the other eight units.

A fuller description of the nine units in the *ICT Literacy* module is contained in Appendix A.

APPLICATION OF ICT IN SUBJECT AREAS

The next stage of the ICT curriculum following the module on *ICT Literacy* is the module titled *Application of ICT in Subject Areas*. This second module is designed for students to learn how to use ICT tools in the different subjects studied in secondary school.

Three broad groups of units comprise the units in the second curriculum module. First, there is a group of five units where applications of the more generic tools and ICT skills in the first module (*ICT Literacy*) are addressed within the main subject areas:

S1 ICT in Languages
S2 ICT in Natural Sciences
S3 ICT in Mathematics
S4 ICT in Social Sciences
S5 ICT in Art

These units are designated S1 through S5, where S denotes subject areas.

Table 4.1. Modules and units in the ICT curriculum for secondary schools

ICT Literacy	Application of ICT in Subject Areas	Infusing ICT across the Curriculum	ICT Specialization
Units	*Units*	*Units*	*Units*
A1 Basic Concepts of ICT	S1 ICT in Languages	C1 Encouragement to reading	*Specialization Preparation*
A2 Using the Computer and Managing Files	S2 ICT in Natural Sciences	C2 Are we becoming genetically modified?	SP1 Introduction to Programming
A3 Word Processing	S3 ICT in Mathematics	C3 Antarctica 2000	SP2 Top-Down Program Design
A4 Working with a Spreadsheet	S4 ICT in Social Sciences	C4 Multimedia and languages	*General Specialization*
A5 Working with a Database	S5 ICT in Art	C5 The parking garage problem	GS1 Foundations of Programming and Software Development
A6 Composing Documents and Presentations	B1 Measurement	C6 The 1920s and its excesses	GS2 Advanced Elements of Programming
A7 Information and Communication	B2 Modelling and Simulation	C7 Le village prologue	*Vocational Specialization*
A8 Social and Ethical Issues	B3 Robots and Feedback Devices	C8 Society's problems	VS1 Business Information Systems
A9 Jobs and/with ICT	B4 Statistics		VS2 Process Control Systems
	B5 Creating Graphics		VS3 Project Management
	B6 Music		
	E1 Spreadsheet Design		
	E2 Database Design		

A second group of units in this module are used in specific subject areas (for example, in mathematics or music). These units are designated B1 through B6, where B denotes the second stage or Stage B:

B1 Measurement
B2 Modelling and Simulation
B3 Robots and Feedback Devices
B4 Statistics
B5 Creating Graphics
B6 Music

A third group of units in this module, El and E2, are extensions of Units A4 and A5 respectively in *ICT Literacy*, and hence the designation E1 and E2, where E denotes extension:

El Spreadsheet Design
E2 Database Design

A detailed description of all units in this module, *Application of ICT in Subject Areas*, is contained in Appendix B.

INFUSING ICT ACROSS THE CURRICULUM

The third stage of the ICT curriculum following I*CT Literacy* and *Application of ICT in Subject Areas* is the module titled *Infusing ICT across the Curriculum*. This third module is designed primarily to aid understanding of how and when to use ICT tools to achieve particular purposes, but without being restricted to particular subjects.

The eight units that comprise this third module are examples of projects that demonstrate the use of ICT in a combination of subject areas where work is done on real-world projects and real problems are solved:

C1 Encouragement to reading
C2 Are we becoming genetically modified?
C3 Antarctica 2000
C4 Multimedia and languages
C5 The parking garage problem
C6 The 1920s and its excesses
C7 Le village prologue
C8 Society's problems

The eight units in this module are designated C1 through C8, where C denotes the third stage or Stage C.

In Appendix C some examples of ICT projects are given to show how - within one course – ICT can help students integrate what they learn across a number of subjects, such as mathematics, science and art. Other examples are of larger projects showing how teachers from differing subjects or from different schools can integrate ICT in community or global projects.

For a detailed description of the eight units in this module, *Infusing ICT across the Curriculum*, see Appendix C.

ICT SPECIALIZATION

The fourth and last stage of the ICT curriculum, following on from the three previous stages, is the module, *ICT Specialization*. This module is designed for students who plan to go into professions that use ICT such as engineering, business, and computer science, or who plan to advance to higher education. The module covers the use of advanced tools and techniques for the ICT specialist.

The *ICT Specialization* module contains three sub-modules. The first of these sub-modules is *Specialization Preparation*, and it contains two units:

SP1 Introduction to Programming
SP2 Top-Down Program Design

where SP denotes *Specialization Preparation*.

The second sub-module, *General Specialization*, contains two units:

GS1 Foundations of Programming and Software Development
GS2 Advanced Elements of Programming

where GS denotes *General Specialization*.

The third sub-module, *Vocational Specialization*, contains three units:

VS1 Business Information Systems
VS2 Process Control Systems
VS3 Project Management

where VS denotes V*ocational Specialization*.

A detailed description of the seven units in the three sub-modules of the *ICT Specialization* module may be found in Appendix D.

V.

PROFESSIONAL DEVELOPMENT OF TEACHERS

Findings of studies of innovation in educational contexts around the world show that many educational innovations ultimately fail because too little effort or too few resources are devoted to preparing teachers for the innovation. Although the primary aim of this book is to develop an ICT curriculum for secondary schools, such development would be insufficient without also considering the professional development of teachers. Therefore, while Chapter IV sets out the structure of an ICT curriculum for students in secondary schools, this chapter takes up the equally important question of how best to prepare teachers for a new ICT curriculum.

The plan for this chapter is first to relate teacher professional development to the approaches identified in Chapter II for ICT development in schools to which it is tied. Next a programme for preparing teachers is developed that closely parallels the ICT curriculum for students described in the previous chapter.

ICT DEVELOPMENT IN SCHOOLS

ICT development in schools was described in Chapter II in terms of a continuum of approaches, commencing with the emerging approach, through to the applying and infusing approaches, to reach finally the transforming approach. These four approaches suggest a framework for the professional development of teachers.

Emerging

In the emerging approach, the focus is on the technical functions and uses of ICT, and on the need for some knowledge of the impact of ICT as a whole. This approach often involves teachers' own personal use of ICT, such as, familiarity with word processing to prepare worksheets, locating learning resources on CD-ROMs or on the Internet, and communicating with friends and family by email.

Applying

In the applying approach, teachers use ICT for professional purposes, focusing on improving the teaching of their subjects so as to enrich how they teach with a range of ICT tools. This approach often involves teachers incorporating ICT to teach specific subject skills and knowledge, beginning to change their teaching methodology, and using ICT to support their personal training and professional development.

Infusing

In the infusing approach, teachers infuse ICT in all aspects of their professional life to improve student learning and the management of learning processes. ICT enables teachers to become active and creative, able to stimulate and manage the learning of students, as they infuse a range of preferred learning styles and uses of ICT in achieving their educational goals. The infusing approach often involves teachers integrating different knowledge and skills from other subjects into project-based curricula. They use multimedia themselves, or make it available to their students to present what they have learned. Teachers may choose to belong to web-based professional development groups to improve their practice or to experiment with different methodologies in order to maximize the impact of ICT on student learning and the management of learning.

Transforming

Teachers and other school staff need to be convinced of the value of ICT personally and professionally. Although the approaches above are not a necessary hierarchy, they are intended to illustrate the steps towards growing ICT

confidence and competence that many teachers go through, before they begin to transform their teaching practice and the learning of their students.

As the infusing approach leads to the transforming approach, teachers and students will expect a continuously changing methodology to meet their personal learning objectives. At the same time, teachers will also expect to be supported as they develop new teaching methodologies. Teachers will no longer be anxious about using ICT, but be concerned about understanding learning processes.

DEVELOPING ICT SKILLS AND KNOWLEDGE

In the emerging approach, teachers are developing their ICT literacy, learning how to apply ICT to a range of personal and professional tasks. The emphasis is on training in a range of tools and applications, and increasing their awareness of the opportunities to apply ICT to their teaching in the future.

ICT literacy is not really different for pupils than for teachers: the basic concepts of understanding and using ICT contain essentially the same elements. Hence, for this basic level of teacher literacy, the same units as for the student curriculum presented in Chapter IV are appropriate. As already indicated, these ICT literacy units have a parallel with the International and European Computer Driving Licence. Of course, the actual use of ICT will be different for teachers than it is for students. Table 5.1 presents a brief description of each of the nine *ICT Literacy* units together with a brief statement of the rationale for their inclusion in a programme of teacher development. An ICT literate teacher should be familiar with all the *ICT Literacy* units.

Conducting professional development

To raise teachers' awareness of the need to become ICT literate, most countries expend considerable effort in public relations around ICT, describing good or emergent practices, organizing discussion sessions, developing informative web sites, and so on.

There are different ways of conducting professional development programmes. Many schools organize meetings and after-school sessions where teachers can be trained in using particular software under the guidance of a fellow teacher, for example, the ICT-coordinator or an expert colleague. Sometimes a lecturer or teacher is engaged from a local teacher education insti-

Table 5.1 Description and rationale for nine ICT Literacy units in a programme of teacher professional development

Unit	Description
A1 Basic Concepts of ICT	• to identify and understand the functions of the main components and of various peripherals of a typical information and/or communication system. • to understand the main functions of the systems software environment in relation to the main generic applications software.
A2 Using the Computer and Managing Files	• to use the main functions of the systems software environment and to utilize its features in relation to the main applications software being used.
A3 Word Processing	• to use a word processor skilfully and intelligently to produce various readable and structured documents.
A4 Working with a Spreadsheet	• to understand and make use of a prepared spreadsheet.
A5 Working with a Database	• to understand and make use of a prepared database.
A6 Composing Documents and Presentations	• to make and use graphical (re)presentations.
A7 Information and Communication	• to understand and be able to communicate with computers online, with sources of information, as well as with other people.
A8 Social and Ethical Issues	• to understand the social, economic and ethical issues associated with the use of ICT. to explain the current situation and trends in computing against the background of past developments.
A9 Jobs and/with ICT	• to be aware of the nature of change of jobs in one's own discipline and in the teacher profession itself, to be aware of the way ICT plays a role in these different jobs.

Rationale
It is not only necessary to know the basic principles of ICT and the use of ICT for personal development but also to cope with the daily life contexts of students and teachers.
It is necessary for all teachers to be able to use ICT for their own purposes and to help students to use ICT.
Word processing is the most commonly used application of ICT. It is helpful to make documents (e.g. letters, tests, and assignments) for teaching purposes and to be able to help students in using word processing. Word processing is necessary for teachers in all subjects.
Spreadsheets are useful for many teaching and personal uses: preparing class lists, mark sheets, and tax returns. Spreadsheets are relevant in all subjects.
Most information systems in use today (e.g. school administration) are based on the principles of databases, and so an understanding of databases is useful for teachers. Databases are also useful in the teaching of many subjects.
As with word processing, the ability to layout documents and make presentations is useful for many teaching purposes. Such abilities are also relevant in the context of multiple learning styles of students.
Using email and searching for information on the Internet is important for teachers personally. It is also important that they can assist students in these basic literacy skills. As schools begin to set up their own Intranets, this unit becomes even more relevant.
It is critical that teachers set good examples for students with respect to such ICT issues as privacy, copyright, backing up of data, and virus protection. Teachers in all subjects need to be role models.
It is part of a teacher's professional development and attitude to know about changes with respect to ICT in the profession, and in a teacher's own subject area, as well as in the general work force that students will enter.

tute or from another school. In some countries, teacher education institutes and other (often private) enterprises provide a range of courses in basic ICT instruction. In other countries, there are accredited organizations for delivering courses of instruction for the International Computer Driving Licence, or similar especially modified units for teachers. In these latter cases, assessment and testing certification is also provided (the computer driving licence).

Learning materials on most aspects of ICT are available on the Internet for self-learning. Teachers often prefer just to explore different software tools, but it is best to organize a systematic programme of professional development for teachers to ensure that all teachers are adequately prepared for an ICT curriculum.

Further points to consider

Teacher education and professional development are essential for the success of an ICT curriculum in schools. A few additional points to consider are the following:

- At the very initial stage, psychological or affective factors are critically important. One of the main goals is to decrease teachers' fears of computers, and to show new learners that they are able to use a computer. Confidence is as important as competence.
- Most of the professional life of teachers is spent at home. Many of the basic ICT skills relevant at this initial stage are of value in their personal lives. Confidence and competence can be acquired through autonomous work, using carefully prepared learning materials and, where possible, some distance interactions through appropriate communication tools.
- Teachers, like all learners, need to be provided with opportunities to make mistakes. Such opportunities are often best provided in arranging professional development programmes for small groups of teachers with similar needs.
- At the initial stage of ICT development, many teachers are affected by serious motor-skill difficulties. The most basic motor skills (e.g. pointing, clicking, and dragging with a mouse) need to be mastered before developing skills to use ICT tools: mastery is about confidence and self-esteem.

- Beginners have not only to be able to use ICT tools and environments, but to understand basic principles about architecture, file managing, and email transmission. Hence, it is important to provide accurate representations of the computing systems and ICT tools they are expected to use in their schools, not the theory of what may happen.

APPLYING ICT TO TEACHERS' SUBJECT AREAS

After teachers have acquired basic ICT skills and knowledge, they feel confident in using a number of generic and specialized ICT tools that can be applied to the teaching of their subject areas. The opportunity to apply ICT in all of their teaching is often limited by a lack of ready access to ICT facilities and resources, and hence is not fully integrated into all lessons for all students.

Specific examples are provided in Appendix B (the student curriculum) to illustrate how teachers can apply ICT in their teaching, in languages, natural sciences, mathematics, social sciences, and art:

S1 ICT in Languages
S2 ICT in Natural Sciences
S3 ICT in Mathematics
S4 ICT in Social Sciences
S5 ICT in Art
B1 Measurement
B2 Modelling and Simulation
B3 Robots and Feedback Devices
B4 Statistics
B5 Creating Graphics
B6 Music
El Spreadsheet Design
E2 Database Design

Teacher competencies

There are general ICT competencies, common to all uses, regardless of the subject area. Training and professional development will need to focus upon these competencies as teachers' technical confidence and competence grows and as they seek ways to improve their teaching.

Examples of general teacher competencies include the following:

Ability to decide why, when, where, and how ICT tools will contribute to teaching objectives, and how to choose from among a range of ICT tools those that are most appropriate to stimulate pupils' learning, that is:

- choose ICT tools and pedagogy from those recommended for specific subjects;
- explain the reasons for choosing particular ICT tools and pedagogy;
- emphasize the content of students' productions;
- plan a whole lesson sequence, deciding in advance when and how ICT will best be used.

Ability to manage a class-based learning environment using team work to achieve teaching objectives, that is:

- be able to describe difficulties in using ICT to achieve planned lesson objectives;
- understand differences between pupils according to their competencies in using ICT;
- have available strategies to manage such differences in the course of teaching.

Ability to decide when whole class or group multimedia presentations will be useful, that is:

- vary the kind of presentation or lesson materials according to the main goals and the teaching method;
- analyze a presentation for legibility, structure, coherence with objectives, and suitability for students.

Ability to analyze subject specific multimedia educational software, that is:

- evaluate CD-ROMs, web sites, video and audio, courseware;
- assess activities proposed for learners and the contribution of these to lesson objectives;
- analyze the specific contribution of ICT tools to individual students' learning.

Ability to assist students to find, compare, and analyze information from the Internet, and from other sources specific to a subject area, that is:

- teach students to construct simple searches;
- help students to manage, to criticize, to synthesize and to present information using ICT tools.

Ability to select and use appropriate tools to communicate, according to teachers' own objectives, with colleagues or with fellow students, that is:

- assess communication tools to use teaching situations to facilitate collaboration.

Ability to use ICT more efficiently, choosing training sessions and participating in new developments in order to enhance professional development, that is:

- participate and be active in groups working on the use of ICT;
- use ICT tools (forums, conferencing, bulletin boards, email) to collaborate in the improvement of teaching and learning and in the management of learning processes.

Organizing teacher development

The ability to use ICT in teaching and be competent in the areas noted above in a given teaching subject requires more adapted training. The way this training is conducted depends very much on the learning style of the teachers involved, as well as on the specific subject and application. The following are two possibilities:

Training courses, seminars and workshops on specific applications used in a teacher's subject area. It is sometimes recommended to include these ICT workshops in accepted conferences within the specific teacher subject community in order to increase the opportunities for participation.

Communities of teachers, set up to achieve a particular goal. In this case, a few teacher colleagues (from different schools, but within the one subject – best number seems to be between 6 and 12 teachers) can decide to work together (perhaps under guidance from the ICT coordinator) on the implementation of a certain ICT topic in their subject

area. They can communicate by means of email but it appears important also to organize face-to-face meetings. The success of these teacher networks is proven, although there are pitfalls to be aware of:

- not too much difference in starting position,
- an equal input from participating members,
- an open mind for sharing experiences,
- involvement of all members,
- task orientation,
- shared responsibility, but also somebody who takes an organizational lead.

Further points to consider

Where schools are at the applying stage, professional development takes on slightly different emphases and priorities compared with the emergent stage. Further points to consider are the following:

- Emphasis is on the use of generic or specialist tools to improve teaching, in particular subject areas.
- Teachers need to be able to assess the contribution of ICT tools to subject skills and knowledge.
- Teachers need to develop their teaching pedagogy as well as further develop their technical confidence and competence in ICT.
- Teachers will still want to control the teaching and learning processes to ensure that lessons are a success: they will only experiment as their confidence with ICT develops.
- Teachers who share the same subject area can work together in their school to pool ideas and the learning resources they have prepared.

INFUSING ICT TO IMPROVE LEARNING

At the infusing stage, teachers are fully integrating ICT in all aspects of their professional life to improve their own learning and the learning of their students. Teachers use ICT to manage their own learning and that of their students. They use ICT to assist all students assess their own learning in completing specific personal projects. It is natural for teachers to collaborate with other colleagues in sharing experiences to solve problems. ICT becomes a stimulus for exciting new teaching opportunities.

Specific examples are provided in Appendix C of how ICT is being used to infuse subject knowledge and skills from across the curriculum to achieve individual learning objectives for students and teachers. The examples illustrate how infusion can be achieved for the individual class teacher working with a single class and for the whole school.

Teacher competencies

There are general competencies and abilities common to all approaches to infusing ICT in learning and the management of learning. The focus of professional development will be on developing the confidence and competence of teachers, building upon their previous education and professional development in applying ICT to teaching.

Professional development in this stage will encourage teachers to collaborate in developing their subject curriculum and identifying innovative teaching methodologies. Opportunities for students and teachers to experiment to identify preferred learning styles and differentiated pathways is encouraged. Infusing ICT across the curriculum to enhance learning and the management of learning leads teachers to an understanding of how to transform their teaching practice as well as the learning of their students. General competencies include, and build on, those at the applying stage.

Examples of general teacher competencies include the following:

Understanding why, when, where, and how ICT tools will contribute to learning objectives; and choosing from among a wide range of ICT tools those that are most appropriate to stimulate students' learning:

- choosing ICT tools and teaching methods that integrate ICT into the whole curriculum;

- choosing and recommending ICT tools and teaching methods appropriate to individual students' learning objectives;
- emphasizing the quality of what students produce and the contribution to individual learning goals and levels of attainment;
- planning a whole learning programme that allows a range of ICT tools and teaching methods to be used, as and when required;
- choosing tools and teaching methods that allow the teacher and student to manage their own learning.

Managing whole school and classroom-based environments, and teamwork to achieve learning objectives:

- managing learning environments that contribute to the use of different ICT tools and teaching methods;
- understanding differences between students according to their competencies in using ICT, and having available strategies to manage differences as students progress;
- managing difficulties that can arise when using ICT to minimize impact on planned lesson objectives;
- creating learning situations such that students manage their own learning;
- infusing ICT-based and non-ICT-based media, such as books and video, into learning programmes;
- assessing the levels of attainment of individual students when working collaboratively.

Infusing multimedia presentations into whole class, group or individual teaching, and learning to increase access to learning programmes:

- ensuring that the most appropriate media are built into learning programmes, that learning is accessible to all students irrespective of ability, special need, or preferred learning style;
- varying the kind of presentation, documents or other media according to the main goals and the chosen teaching method;
- analyzing a presentation for legibility, structure, coherence with teaching objectives, and suitability for students.

Analyzing multimedia learning environments:

- utilizing web-based learning spaces and environments;
- including CD-ROMs, web sites, video and audio, courseware;
- assessing the contribution of different activities to learners and the lesson objectives;
- analyzing the specific contribution of ICT tools to individual student learning.

Supporting students to find, analyze and synthesize information from disparate Internet and school-based learning environments:

- supporting individual students and groups of students to perform complex web searches;
- supporting students in managing, criticizing, synthesizing, and presenting learning processes and products using ICT tools.

Utilizing a range of communication tools to collaborate with colleagues, with students, and other learning communities beyond the school.

Using ICT more proficiently, regularly taking part in professional development, and participating in teaching experiments and developments:

- participating in, and contributing to, group discussions on the use of ICT;
- using ICT tools (forums, conferencing, bulletin boards, email) to collaborate in the improvement of teaching and learning and management of learning processes.

Organizing teacher development

The kind of teacher activities described in this section on professional development cannot be obtained through short courses, seminars or workshops. These forums can be used as appetizers to inform teachers about infusing ICT into all teaching activities but teachers cannot be expected to achieve all this as a result of just a short course. Most effective for this kind of teacher development is teamwork and educational leadership within a school.

A good starting point for teacher development is to form a group of enthusiasts within a school. Later, this group can be extended to larger groups of teachers from different schools, and even teachers from different districts, states, or countries.

Where teacher networks can be built on teachers from different schools as described under the applying approach above, such networks should preferably involve some teachers from each school from different subject areas. Because the way of working in a totally integrated way is so different from what most teachers are used to, it is most important to share experiences, adopt common goals and tasks, have involvement and equal input from all teachers, and have others to lean on and give support when things do not go quite as expected.

It is often valuable to involve students themselves in the work of a community. Students can often take responsibility for activities and frequently have the necessary ICT expertise needed in a particular project.

Further points to consider

Two further points to consider are the following:

One of the roles of a teacher is to help students transform information, which is everywhere and in enormous quantities on the Internet, into knowledge that only exists in human brains, and then into wisdom so that they can transform their own lives and the communities to which they belong.

As ICT puts stress on teamwork and on teacher collaboration, teacher education and professional development needs to be organized, not for individuals but for teams, that are both local and global, and where learners are co-learners.

SUPPORTING INFUSION OF ICT IN SCHOOLS

Infusing ICT throughout a school needs (as in other areas of the school curriculum) human resources to support users' work and needs. Hence, there must be experts or specialist teachers who are available to spend a great amount of time acting as resource persons or ICT coordinators. Without this kind of human support, infusion unfortunately will not take place, however favourable other school factors are in creating a supportive climate for ICT.

Sometimes this support person is also the one who teaches the *ICT specialization* units in a school, though other teachers can also undertake this support role. The more specialized ICT curriculum units listed under the *ICT specialization* in Appendix D will, of course, need to be taught by specialized teachers. Professional development for these teachers is not addressed here, other than to note that additional specialization on top of a teacher education qualification is normally undertaken in tertiary institutions in departments of computer science.

Role requirements for support teachers in ICT

In this section, the more essential role requirements of a resource person or ICT co-ordinator are elaborated. Such a person will need the ability to do the following:

Collaborate with the school management and administration:

- be precise, in agreement with management, about their role, availability, and modes of intervention according to act;
- regularly inform management about the progress of activities and projects;
- disseminate the results of any experiments in the use of ICT undertaken inside or outside the school;
- develop a global view on needs and means with respect to ICT support for teaching and learning.

Be responsible for policy concerning technical infrastructure:

- be responsible for the availability and usability of computers and networks within a school;
- be the intermediary between school and hardware or software providers, and between school and other educational institutions.

Support teachers in infusing ICT in their teaching practice:

- propose lines of development for infusing ICT by suggesting, showing examples, or providing motivation on the use ICT;

- help teachers to be trained, in accordance with their needs and requests, by proposing training resources, by assuming training sessions, and by enabling the sharing of knowledge and experiences between teachers (on the basis of their personal competencies);
- accompany teachers on occasion within the classroom, to provide backup and to offer support;
- encourage emerging successes arising from team projects using ICT.

Give support to ICT team projects:

- help teaching teams to make their ICT-based projects more precise by showing what is possible, setting limits, and assisting teams to specify their training needs;
- help with planning and scheduling of team projects;
- help with implementation, make resources available, and even take part in the realization of projects;
- cope with relations between teachers in a team to ensure that individuals agree with the aims of a team project, and to manage any conflicts within a team;
- help a team to evaluate process and outcomes, and to schedule steps in evaluation of projects.

Promote ICT uses inside a school and facilitate these uses:

- develop and support the use of email, and share communication solutions via the school Intranet;
- discuss and set up procedures for accessing and using ICT resources, and reach agreement with users about access;
- organize how ICT resources can be accessed and used by teachers and students.

Support specialized student activities with ICT:

- without taking the place of, or without playing the role of, other teachers, and in agreement with these teachers, help any students who face special problems in using ICT;
- organize special training sessions, and arrange meetings of teachers and students to demonstrate or discuss advanced features or tools.

Organizing teacher development

It is essential that ICT co-ordinators or other ICT resource personnel should continue their own professional development. This development will involve mastering new technical and teaching competencies required due to technical evolution and changes inside a school organization. It also involves communicating and exchanging experiences with other school ICT co-ordinators.

For *ICT Specialization*, teachers need on occasion to attend special courses, which in some countries include examination, leading to certification as teachers of computer studies or informatics.

VI.

A BLUEPRINT FOR CURRICULUM AND TEACHER DEVELOPMENT

Chapter II presents two models that form the basis of the ICT curriculum for schools and the programme of teacher development put forward in subsequent chapters. Models are useful for providing a framework, a structure for showing how different components of a complex system interconnect and interrelate. This chapter brings together the key themes of all previous chapters in a succinct form as a blueprint for future action by policy-makers, educational administrators, teachers, and textbook writers.

MODELLING ICT DEVELOPMENT

The two models presented in Chapter II are derived from international studies of trends in ICT development in schools, with a particular focus on secondary schools.

The first model portrays ICT development in schools as a continuum of approaches to ICT adoption. At the start of the continuum, the approach is termed *emerging*, where schools begin to use ICT and add ICT to the curriculum. With a school's greater involvement in ICT, the emerging approach leads into what is termed the *applying* approach, where teachers make increasing use of ICT in subjects they teach. Further along the continuum of adoption of ICT comes what is termed the *infusing* approach, where the boundaries between the various subjects taught in secondary schools begin to break down as ICT is used in cross-curriculum projects that more closely resemble problems in everyday life. The final approach at the end of the continuum is termed *trans-*

forming, where the roles of teachers and learners are transformed, the curriculum being learner-centred rather than teacher-centred, and ICT is seamlessly applied routinely to perform educational tasks in new and creative ways.

The second model portrays the stages of teaching and learning through which teachers and students progress as they become more familiar and gain confidence in the use of ICT. The first stage in the model is *discovering ICT tools*, a stage that leads on to *learning how to use ICT tools* in different subject fields. The next stage is *understanding how and when to use ICT tools* to achieve particular purposes, while the last stage is *specializing in the use of ICT tools*.

TRACKING ICT DEVELOPMENT IN SCHOOLS

The first model of a continuum of approaches to ICT development (emerging, applying, infusing, transforming), together with key characteristics of schools relating to ICT (e.g. vision, philosophies of learning and teaching, facilities and resources), gives rise to a matrix for ICT development in schools. This matrix, presented in Chapter III, is useful for policy-makers and educational administrators in tracking where individual schools are at with respect to ICT development.

A BLUEPRINT FOR CURRICULUM

The second model that depicts teaching and learning about and with ICT in terms of four stages (discovering, learning how, understanding how and when, and specializing in) is helpful in providing a curriculum structure for secondary schools. This curriculum structure, presented in Chapter IV, contains four curriculum modules:

- *ICT Literacy* (where ICT skills are taught and learned as a separate subject);
- *Application of ICT in Subject Areas* (where ICT skills are developed within separate subjects);
- *Infusing ICT across the Curriculum* (where ICT is integrated or em-bedded across all subjects of the curriculum); and
- *ICT Specialization* (where ICT is taught and learned as an applied subject or to prepare for a profession).

Chapter IV details these four curriculum modules and the units that comprise each module. More specific detail of the content of all units is located in the four appendices that follow this chapter, one appendix for each curriculum module.

A BLUEPRINT FOR TEACHER DEVELOPMENT

Without an accompanying programme of teacher development, an ICT curriculum for schools will almost certainly fail to succeed. Chapter V presents a blueprint for teacher development that is linked to the curriculum for schools detailed in Chapter IV and in Appendices A, B, C, and D.

The programme of teacher development outlined in Chapter V clearly needs to relate to the four curriculum modules in the curriculum for secondary schools. At the same time, teacher development is an on-going process that should be linked to a school's progression along the ICT development continuum (emerging, applying, infusing, and transforming). How a programme of teacher development best relates to ICT curriculum and to where a school is at in terms of ICT development is described fully in Chapter V.

A BLUEPRINT FOR TEXTBOOK WRITERS

The ICT curriculum and accompanying programme of teacher development have been designed to be of use to many countries in many circumstances. The level of description is of necessity general rather than particular. The curriculum description and teacher development programme do not, nor can they, take into account particular conditions in particular contexts. Nevertheless, the detail, particularly in the appendix material that follows, is such that textbook writers will be able to produce texts suitable for teaching in local situations.

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APPENDICES

The four appendices that follow specify an ICT curriculum for secondary schools. The ICT curriculum is subdivided into four broad areas termed *modules* that are briefly described in Table A.1.

Table A.1 Four curriculum modules comprising the ICT curriculum for secondary schools

Module	Name of Module	General Description
A	ICT Literacy	Designed for students to discover ICT tools and their general functions and uses.
B	Application of ICT in Subject Areas	Designed for students to learn how to use ICT tools in the different subjects studied in secondary school.
C	Infusing ICT across the Curriculum	Designed to aid understanding of how and when to use ICT tools to achieve particular purposes, but without being restricted to particular subjects.
D	ICT Specialization	Designed for students who plan to go into professions that use ICT such as engineering, business, and computer science, or who plan to advance to higher education.

The four curriculum modules and the units that comprise each module are elaborated in Appendices A, B, C, and D respectively. The detail for each unit generally indicates broad and specific unit objectives, the context for teaching the unit, content coverage, links to other units, teaching methodology, and resources required.

The ICT curriculum has been developed to be of use to many countries in many circumstances. The level of description is sufficiently detailed for textbook writers and educational publishers to be able to produce texts for teaching in a local situation.

APPENDIX A – ICT LITERACY

CONTENTS

The module, *ICT Literacy*, is the first stage of the ICT curriculum. This first module is designed for students to discover ICT tools and their general functions and uses. The module comprises nine units:

Al Basic Concepts of ICT
A2 Using the Computer and Managing Files
A3 Word Processing
A4 Working with a Spreadsheet
A5 Working with a Database
A6 Composing Documents and Presentations
A7 Information and Communication
A8 Social and Ethical Issues
A9 Jobs and/with ICT

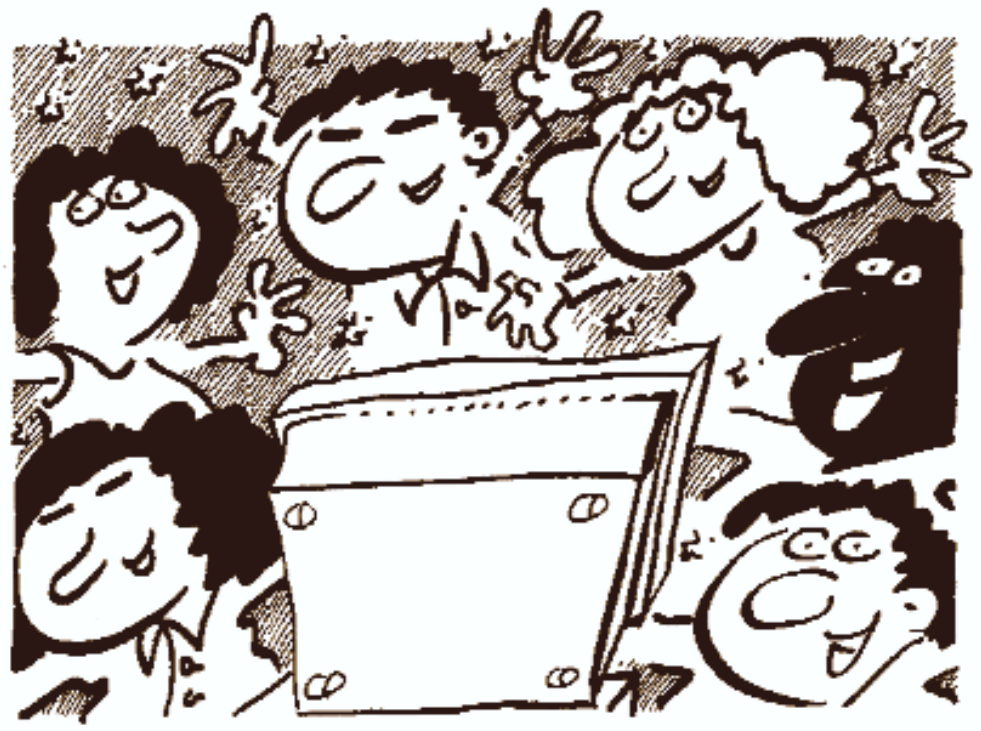
Unit A1 may be integrated with the other units in this module.

UNIT A1 – BASIC CONCEPTS OF ICT

This unit can be used on a need-to-know basis during the teaching of other units. It is designed to give theoretical background for the practical work in the other units.

Objectives

Students should be able to identify and understand the functions of the main components of a typical information and/or communication system as well as identify and understand the functions of various peripherals. They should be able to understand the main functions of a system software environment and to utilize its features in relation to the main applications software being used.



Students should be familiar with basic concepts of ICT

Sub-objectives

Students should be able to:

- identify the main components of the hardware in use (i.e. Central Processing Unit (CPU), input devices, output devices and storage devices);
- demonstrate an understanding of the functions of the main components of the hardware in use;
- identify various peripheral devices (e.g. modem, fax-modem, plotter, scanner, digital camera);
- demonstrate an understanding of the functions of the various peripheral devices;
- demonstrate an understanding of the local network in use in relation to the external network (e.g. Internet) and the use of email;
- demonstrate an understanding of the main functions of the system software environment;

- demonstrate an understanding of the features of the system software environment (to the appropriate level) in relation to the main applications software.

Context

Students should understand how computers and the basic operating system work and demonstrate that the computer is under their control. They should be encouraged not to be mystified by computers and should be able to understand that computers are continually being improved and why.

Content

Students should be able to differentiate between the basic components of a computer system and understand the function of various peripheral devices. Students should know what system software is and how the use of this software relates to the operating systems software. They should be aware of the connectivity of computers in a local and an external network and be familiar with the appropriate functions of such networks.

Links

All other A-units in the *ICT Literacy* module.

Methodology

Unit Al presents an introduction to *ICT Literacy*, but can also be used in combination with the practical work in other A-units in this module.

Explanations with diagrams, video and real objects, and field trips where necessary.

Resources

Minimum necessary resources	Optional extra resources
Diagrams, models of the basic computer components; illustrations of their functions; actual samples or illustrations of peripheral devices. System software, such as Windows, for demonstration.	Videos, visits to computer facilities, computer-building kits. Dated, but not obsolete computer to take apart.

UNIT A2 – USING THE COMPUTER AND MANAGING FILES

Unit A2 could be omitted if students have had sufficient practical experience with computers in primary school.

Objectives

Students should be able to use the main functions of the system software environment and to utilize its features in relation to the main applications software being used. They should be able to show competence in using a computer to generate simple things such as posters, banners, signs, invitations cards, calendars and drawings.

Sub-objectives

Students should be able to:

- use the features of the system software environment (to the appropriate level) in relation to the main applications software;
- use network functions (if available) to the appropriate level;
- demonstrate the ability to use a computer competently to produce posters, banners, signs, invitation cards, calendars and letterheads using simple software;
- experience the enjoyment and stimulation of using computers.

Context

This unit is aimed at teaching students how to use a computer system (on a need-to-know basis) so that they can use the system competently to achieve their tasks. These first experiences in using a computer should be fun and stimulating. Educational games, good computer-supported learning packages, and simple graphics software can give students a sound introduction to using a computer for the first time.

Content

Students should know how to operate a computer system and its peripherals as well as the commands necessary to use the software to produce required outcomes. They should also know the various steps and com-



Students should feel confident about using computers

mands needed to perform a variety of tasks such as formatting a disk, copying a disk, making directories and sub-directories, hard-disk management, unformatting, saving and renaming files. Where applicable, students should also be familiar with the appropriate functions of the local or wide area network available to them.

Teachers should give meaningful and directed exercises so that students have a definite objective to aim for. If necessary, teachers may illustrate the functions of the various components of the computer in terms of input, processing, output and memory.

Links

All other A-units in the *ICT Literacy* module.

Methodology

Student-centred activities, hands-on activities, on a guided basis for the system operation activities, and on a creative, self-exploratory basis for the production activities.

Resources

Minimum necessary resources	Optional extra resources
Computer, system software. Easy-to-use software for designing and making simple graphics. Printer.	Examples of various creations made with available software.

UNIT A3 – WORD PROCESSING

Objectives

Students should be able to use a word processor skilfully and intelligently to produce various readable and structured documents in several subjects they are studying.

Sub-objectives

Students should be able to:

- produce a readable document;
- produce a structured document;
- produce documents for various purposes;
- discuss the advantages and disadvantages of a word processor in a variety of settings;
- make informed decisions as to whether a word processor should be used for a given task.

Context

Ability to use a word processor is necessary in today's society. Few people use typewriters when a computer provides a better alternative. There are clear advantages of using a word processor compared to the usual method of writing on paper or typing with a typewriter. Students should appreciate the use of a word processor and be encouraged to use it for most writing tasks. The objective is not to train qualified typists or secretaries, but keyboard skills and knowledge of word processing are an advantage when seeking employment.

Content

Students should first learn how to use a word processor under the supervision of a teacher who should demonstrate and emphasize how easy it is to use. Students should start by entering simple, but meaningful exercises. They should know how to use the various features (e.g. bold, italics, underline, justified margins, centring, superscript, subscript, fonts, headers and footers, tables, replace text and insert data) provided by word processors and be able to use additional utilities such as spell templates, checkers, grammar checkers, dictionary, thesaurus and merge facilities. Meaningful activities on a word processor include the preparation of personal or business letters, invitations to school events, and lists of school events. Students should be able to use a word processor independently to produce various documents that are readable and structured in a presentable form. They should also be able to make informed decisions about whether or not a word processor is the most efficient method for particular tasks.

Links

All other A-units in the *ICT Literacy* module.

Methodology

Student-centred, hands-on activities.

Teachers may initially create simple exercises such as sample documents on disks, and require students first to open, modify and re-save files; then to progress to more difficult exercises such as the use of headers, footers, dictionary, thesaurus, spelling and grammar checkers.

Resources

Minimum necessary resources	Optional extra resources
One computer per student, word processing software; Teacher prepared materials (exercise sheets, sample files).	Easy to understand manuals on the word processing software; Multimedia projector and overhead projector; Magazine articles on word processors; Advertisements and brochures on word processors available in the market.

UNIT A4 – WORKING WITH A SPREADSHEET

	A	B	C
1	Estimated Yearly Expenses		
2			
3		Jan-Apr	Year (est)
4	Groceries	2943	8829
5	Clothes	451	1353

Students should understand the use of simple spreadsheets

Objectives

Students should be able to understand and make use of a prepared spreadsheet.

Sub-objectives

Students should be able to:

- demonstrate an understanding of what a spreadsheet is and its uses;
- use a prepared spreadsheet to change values of variables and to see their various effects;
- demonstrate an understanding of the uses of a spreadsheet.

Context

Spreadsheets are useful tools for individual or group work, and are widely used in industry and commerce. Students should understand what a spreadsheet is, how easy it is to manipulate variables, and they should see the effects of this manipulation.

Content

Students are introduced to the concept of a spreadsheet and the components in a spreadsheet. They manipulate a spreadsheet by changing values in cells, and will also, perhaps, change formulas to see the effects. Graphs, based on the

values entered in the cells, may be generated automatically. Students should also be able to understand the various uses of a spreadsheet in daily tasks.

Links

All other A-units in the *ICT Literacy* module.

Methodology

Demonstrations, student-centred, hands-on activities.

Resources

Minimum necessary resources	Optional extra resources
Computers for group work, spreadsheet software. Teacher-prepared spreadsheets.	Ready-made spreadsheets. Multimedia projector and overhead projector. Tutorial software.

UNIT A5 – WORKING WITH A DATABASE

Objectives

Students should be able to use a prepared database in a competent manner.

Sub-objectives

Students should be able to:

- understand some of the relevant phases of problem solving;
- identify a problem that can be solved by a database;
- use a prepared database to store information;
- draw and interpret information from an existing database in a structured and rational manner.

Context

In a large variety of businesses and in everyday life, data are stored in databases managed by computers, which are increasingly being linked together, for example for airline and hotel reservations. More and more information about people is stored in databases, and students should therefore be aware of the need to protect personal data.

Content

Students analyze different applications in every day life where databases are used. Whenever possible, examples should be used that make the need for data protection obvious, such as: student records, information about tourist flows and needs.

Using a suitable example, the teacher prepares the appropriate structure of a database. Students then collect the necessary data, for example, by interviews for which they must design an appropriate questionnaire. The data are entered into the database. Different lists can be produced and discussed. During the process of using a database, students will come to understand some aspects of problem solving such as design, data entry and modification, and how to question the database.

Links

All other A-units in the *ICT Literacy* module.

Methodology

Student-centred, hands-on activities.

Resources

Minimum necessary resources	Optional extra resources
One computer per group of students. Simple filled databases. Some countries provide simple educational databases or special user interfaces for students at a reasonable price.	One computer per student; tutorial software. Multimedia projector and overhead projector.

UNIT A6 – COMPOSING GRAPHICAL (RE)PRESENTATIONS



Students should be able to use graphics appropriately

Objectives

Students should be able to use graphical (re)presentations in an appropriate way.

Sub-objectives

Students should be able to:

- identify the use of different forms of graphic representations in every day life;
- understand the link between data and graphics;
- convert data into appropriate graphic presentations;
- use text and appropriate graphics to make a presentable document or presentation;
- produce simple web pages with text and graphics;

- see the consequences of different forms of graphic representations of the same data;
- identify cases where it is appropriate to use graphics, and select which graphics to use.

Context

"A picture can tell more than a thousand words". A large variety of reports can be illustrated by different graphic representations, for example, line graphs, bar charts or pie charts. Data can be shown in appropriate or inappropriate ways, the latter leading to misinterpretation of the original data. Familiarity with the ways in which graphs are used will help students to present their work clearly in many subject areas and in their working lives. In addition, the ability to present one's findings in a proper and clear way is needed in today's information age.

Content

Students analyze different applications in everyday life where graphic representations are used. Whenever possible, examples should be used which make an inappropriate use obvious. Examples might be found in the school environment, in data about the community, in the business world, and in the daily or weekly newspaper. Current data and data from earlier years should be illustrated in different forms.

Text, data and graphics can be used in a variety of presentations: written documents, presentations and web pages.

Links

All other A-units in the *ICT Literacy* module, but especially Unit A3 *Word Processing*.

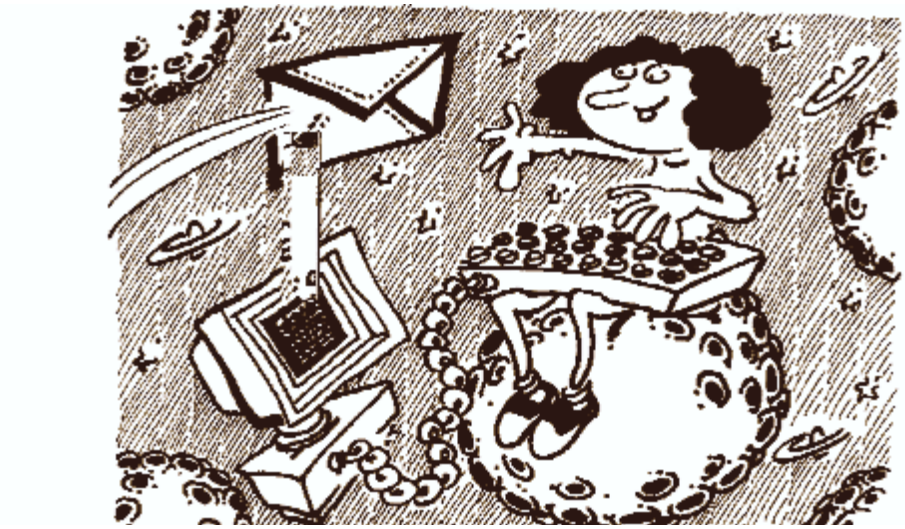
Methodology

Student-centred, hands-on activities, and a variety of examples of graphical representations illustrated.

Resources

Minimum necessary resources	Optional extra resources
One computer for each group of students with a graphics software package and software for presentations, writing and Web design. Examples from industry and commerce.	Advanced graphics software. Multimedia projector and overhead projector.

UNIT A7 – COMPUTERS AND COMMUNICATION



Students should be familiar with using computers to communicate

Objectives

Students should be able to demonstrate an understanding of how you can communicate with a computer online for sources of information, as well as with other people using a network.

Sub-objectives

Students should be able to:

- show understanding for the way you can communicate, exchange and collaborate within an ICT network;

- identify the various methods and types of activities of communicating via a network;
- send and receive messages and documents by using email facilities;
- retrieve information by navigating, searching and selecting information from the Internet and the World Wide Web;
- be critical about the quality of all information, and acknowledge the ownership and privacy aspects of information;
- subscribe to mailing lists and newsgroups, and participate in video-conferencing;
- send, receive, read and print faxes using a fax-modem and an appropriate software tool.

Context

In an information society, students can get information quickly from appropriate sources and they can exchange information and collaborate speedily with others throughout the world. With the increasing use of the Internet, it is necessary that students have a clear but critical understanding of the possibilities of the World Wide Web. Students should know the various sources of information available to them and how to access these.

Content

Students should understand the various means of electronic communication such as electronic mail, chatting and mailing list, use of Internet and the World Wide Web, faxing with the computer and modem; and should be able to make critical and conscious choices for the information they want to gain.

Links

All other A-units in the *ICT Literacy* module, especially Unit 8 *Social and Ethical Issues*.

Methodology

Hands-on experience, searching for information, and using email.

Resources

Minimum necessary resources	Optional extra resources
One computer per group and communications software. Connection to the Internet. Email and fax facilities.	Multimedia projector and overhead projector. Email facilities. Video-conferencing facilities.

UNIT A8 – SOCIAL AND ETHICAL ISSUES

Objectives

Students should be able to understand the social, economic and ethical issues associated with the use of computers. They should be able to explain the current situation and trends in computing against a background of past developments.

Sub-objectives

Students should be able to demonstrate an understanding of:

- the benefits and drawbacks of computer use to society in general;
- the economic advantages and disadvantages of the use of computers;
- the ethical questions that have arisen as a result of computer use with respect to privacy aspects, copyright issues and computer viruses;
- the current situation and trends in computing against the background of past developments in a) hardware; b) software; and c) ways of operating.

Context

Where are we going? In order to answer the question we have to know where we have come from. The world of computing will be very different by the time students enter the work place, but many of the changes are predictable if we study the trends up to now. In addition, we have to know some of the history of computing in order to understand the terminology and procedures we find today.

Students should be made to realize that computers do not always contribute positively to society. They should appreciate the seriousness of the social, economic and ethical issues that have arisen over the years. There can be misuses and abuses as well as unethical behaviour by those in control of computing facilities. Students should be aware of such behaviour and how it can be corrected.

Content

Students should understand the key stages in the evolution of computers over the years. This may be looked at from the following points of view:

- early history (weaving, calculating machines, code breaking);
- CPU development (improvements in speed and power versus decrease in price, size and energy consumption);
- input devices (developments from punched cards to the mouse and speech recognition);
- output devices (from teletype to video display units);
- storage devices (from punched paper to hard disks);
- software (from changing the wiring to user-friendly software tools);
- text and document processing (leading to the "paperless office"); and
- operating methods (developments from batch processing and time-sharing to local and wide area networks, multi-tasking and distributed processing).

Students are expected to understand basic concepts such as computer crime and fraud, equity, intellectual ownership, privacy of information, links between automation and unemployment, and computer security (theft, hacking, viruses).

Links

All other A-units in the *ICT Literacy* module.

Methodology

Discussions; student-based research.

Visits to facilities having earlier and recent computer hardware.

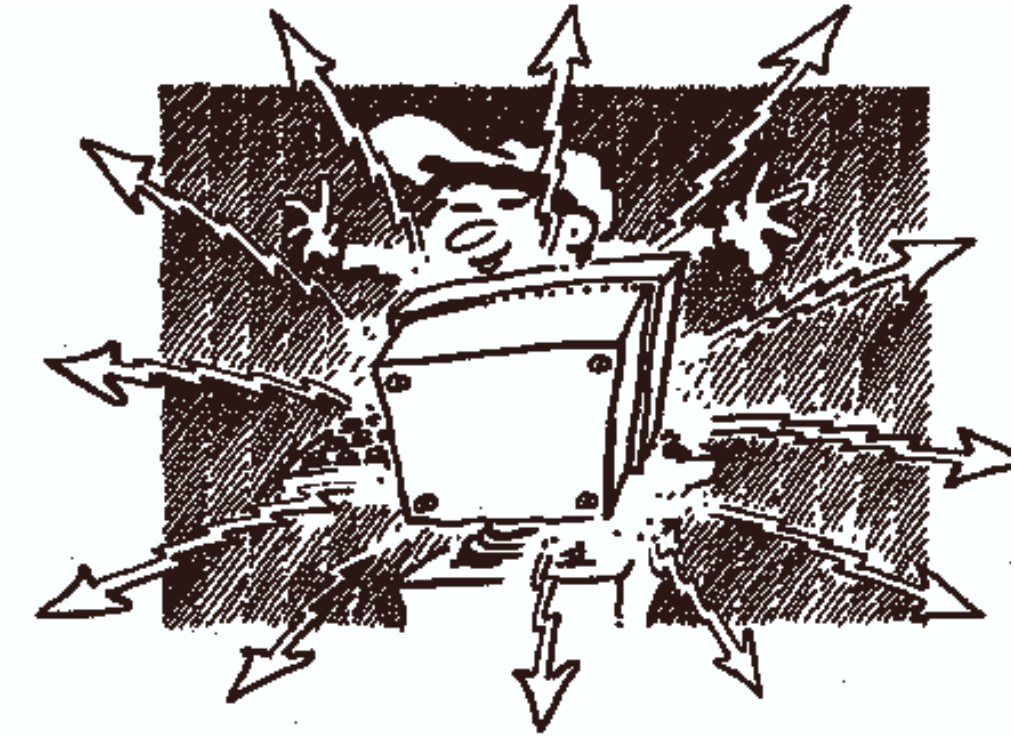
Resources

Minimum necessary resources	Optional extra resources
Pictures or illustrations of earlier computers.	Suitable books, newspaper clippings of newly launched computer hardware or software, newspaper articles of soon-to-be-launched or future hardware and software, videos, examples of hardware, software and peripherals.

UNIT A9 – JOBS AND/WITH ICT

Objectives

Students should have some awareness of the nature of jobs in ICT and the way ICT plays a role in many other jobs.



Students should be aware of how ICT changes jobs

Context

The titles and job descriptions of ICT personnel have grown out of IT history and are not self-explanatory, even to computer literate persons. Insight into professional applications of what students learn at school is part of most curricula; but because of a lack of understanding of how important ICT is in the professional environment today and how "human" ICT workers are, it should be an essential part of the ICT curriculum. Many students will contemplate a career in ICT or reject such a career for the wrong reasons. They should be helped to make informed choices.

Content

Students should research and report on careers available in the computer industry, including systems development and the provision of services. They should have some insight into the applicability of ICT in other disciplines.

Links

All other A-units in the *ICT Literacy* module, especially Unit 8 *Social and Ethical Issues*.

Methodology

This unit provides a good opportunity to send students or groups of students out to interview ICT practitioners or other people whose work is very much influenced by ICT, and to interpret the information gathered. The use of a word processor and a presentation tool should be appropriate to illustrate the results of such research. Qualification survey graphs could also be created. A spreadsheet could be used to list and compare variables, for example, investment in training versus potential income.

Resources

Minimum necessary resources	Optional extra resources
Careers opportunities listed in the library.	Presentation packages. Projection facilities.

APPENDIX B – APPLICATION OF ICT IN SUBJECT AREAS

Contents

The module *Application of ICT in Subject Areas* comprises three broad groups of units. First, there is a group of five units where applications of the more generic tools and ICT skills in the first module (*ICT Literacy*) are addressed within the main subject areas:

S1 ICT in Languages
S2 ICT in Natural Sciences
S3 ICT in Mathematics
S4 ICT in Social Sciences
S5 ICT in Art

Second, there is a group of units that are used in a specific subject area like mathematics or music:

B1 Measurement
B2 Modelling and Simulation
B3 Robots and Feedback Devices
B4 Statistics
B5 Creating Graphics
B6 Music

Third, there are two units that are extensions of Units A4 and A5 respectively in *ICT Literacy*:

El Spreadsheet Design
E2 Database Design

UNIT S1 – ICT IN LANGUAGES

Many examples of the use of ICT can be introduced in language teaching. Here are a few.

Word Processing

The most common application of ICT in languages is word processing (see Unit A3 *Word Processing* in Appendix A) to create, for example, letters and other documents.

Teachers can create cloze reading texts (texts with missing words or words missing punctuation, plural or tense endings) for students to complete. Arranging a story in chronological order, or completing a story or an outline, are other valuable applications. Using spelling and grammar checkers in a proper way can give students a feeling of self-confidence when producing written texts.

Composing Documents and Presentations

An extension of Unit A6 *Composing Graphical (Re)presentations* (see Appendix A) is composing documents and making presentations. Students find it motivating to produce reports on topics in their mother tongue or a foreign language using ICT tools. To illustrate what they produce gives students an impetus to write. Students appreciate adding ready-to-use graphics or graphics that they create themselves.

Information and Communication

An extension of Unit A7 *Computers and Communication* (see Appendix A) is searching for information and communicating with foreign speakers. Nothing seems to be more motivating for students than to communicate with a native speaker of a foreign language in a distant country. More equality can be reached by communicating in the foreign language with other non-native speakers in other countries. Setting up email links such as in the Australian project *Computer Pen Pals* or in the French initiative *Mini Web*, *Multilingual and Maxi learning (MMM)* project is very effective. In the future, video-conferencing will be a quite normal way to communicate online.

The information that is available on the Internet about a foreign country and in a foreign language can be used in many different ways: to give assignments and tasks to students (e.g. in combination with the production of presentations), to provide context and cultural background information, and to make classroom learning more real.

Finally, there is a considerable amount of information on the Internet or contained on specific CD-ROMs about writers and books: databases, excerpts, reviews, opinions, and so on. This ready access will change the nature of language teaching because this information is so easy to access.

Speech Recognition and Synthesis

Given the right software, students can compare their own pronunciations with those of a synthesized model, both orally and visually.

UNIT S2 – ICT IN NATURAL SCIENCES

A few of many ways that ICT can be used effectively in the teaching of natural science subjects are illustrated in the following examples.

Spreadsheets

Students can use spreadsheets (an extension of Unit A4 – see Appendix A) to tabulate and calculate results of experiments. The use of spreadsheets is the clearest and quickest way to demonstrate how manipulating a particular variable produces certain effects. Students can also request various types of charts to be plotted from values entered into a spreadsheet.

Teachers can prepare templates that have values already entered to illustrate effects of manipulating variables, which is most appropriate for work on simulation and modelling.

At a more advanced level, spreadsheets can be designed by students themselves in order to help solve realistic and contextual problems (see Unit E1 below in this module).

Databases

Students can create and use databases (an extension of Unit A5 – see Appendix A) for storing variables such as the characteristics of chemical elements in the periodic table, characteristics of plants, insects, and mammals; and then interrogate these databases to find relationships and commonalties. As a first step, teachers can prepare databases into which students can add data.

At a more advanced level, databases can be designed by students themselves in order to help to solve realistic and contextual problems (see Unit E2 below in this module).

Composing Documents and Presentations

Students can use a word processor or presentation software (extensions of Unit A3 and A6 – see Appendix A) to report on the results of experiments or research they conduct. Students will appreciate adding ready-to-use graphics, or graphics that they create themselves. They can also use data and graphs created from measurement software (see Unit B1 below in this module).

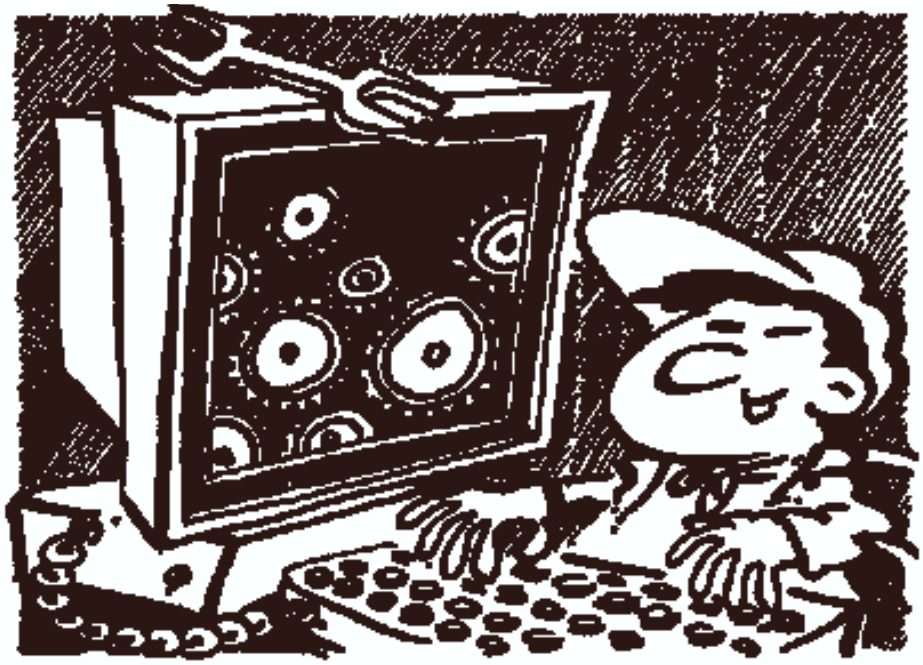
Information and Communication

Students can use ICT tools to communicate (an extension of Unit A7 – see Appendix A) with other students on a local network, or with students in other schools, both locally and overseas. For research and for specific assignments, information available on the Internet can be used. Online data can be retrieved and shared with others about topics such as the weather, the state of the environment, space programmes, and so on.

Furthermore, use can be made of readily available easy-to-use applets to simulate all kinds of natural processes and phenomena.

Measurement

Using mechanical, temperature and other probes to monitor experiments, and feeding the readings directly into a spreadsheet or graphical program, helps to obtain reliable results more easily and makes classroom work more realistic. Several software tools exist that take readings, present these graphically, and aid interpretation. See also Unit B1 below in this module.



Students can build and use robots to perform experiments

Modelling and Simulation

The Three-mile Island disaster can be simulated in classrooms without any danger to students. When students have performed or have witnessed a demonstration, repeating the experience through modelling will give them further insight into the role of variables and parameters in a process. See also Unit B2 below in this module.

Robots and Feedback Systems

Students can build robots and use robotics to perform experiments, particularly in physics and technical areas. They may arrange for input from sensors, processing, output and feedback. See also Unit B3 below in this module.

UNIT S3 – ICT IN MATHEMATICS

There are numerous ways for applying ICT in mathematics subjects to motivate students and to demonstrate the utility of mathematics in real life.

Spreadsheets

From doing repetitive calculations to showing patterns in certain number manipulations, spreadsheets (an extension of Unit A4 – see Appendix A) can play an important role in mathematics at most levels. With spreadsheets, students can manipulate variables or parameters to see certain effects clearly and quickly. Students can also request various types of charts to be plotted from values entered into a spreadsheet.

Teachers can prepare templates which have values already entered in order to illustrate effects from manipulating variables, which is appropriate for work on simulation and modelling. At a more advanced level, spreadsheets can be designed by students themselves in order to help to solve realistic and contextual problems (see Unit E1 below in this module)

Information and Communication

Students can use applets that are readily available on the Internet (an extension of Unit A7 – see Appendix A) for performing mathematical activities and solving certain mathematical problems.

Modelling and Simulation

Students can use simple modelling packages, such as Mathematica, to gain insight into mathematical functions. Graphic calculators can also be used for this purpose. Such ICT tools are likely to change – some say completely – the curriculum of mathematics itself. Their use gives students access to easily applied tools for performing tasks that they would previously have had to learn before such tools became available. What all this implies is a shift from the mechanical task of drawing graphs for functions to the higher order learning skill of interpreting graphs drawn with ICT tools, and in the process changing the way that mathematics is taught.

Modelling and simulation can also be used with special software for geometry and stereometry to give students a greater understanding of figures in two- and three-dimensional space. See also Unit B3 below in this module.

Statistics

Suitable statistical software tools eliminate hours of calculation in statistical analyses, thus allowing students to focus more on interpreting results. Again, these kinds of ICT tools are changing the way mathematics is taught. See also Unit B4 below in this module.

UNIT S4 – ICT IN SOCIAL SCIENCES

The teaching of social science subjects can be greatly enhanced by the use of ICT as the following examples illustrate.

Composing Documents and Presentations

Producing reports using ICT tools in history, geography or economics topics is highly motivational for students. Students enjoy adding graphics, photographs, pictures, and other information about a topic to reports they write and presentations they make.

Information and Communication

A whole range of graphical information, including diagrams, photographs and other pictures, is readily available on the Internet. Other information can be researched using the Internet to include in reports, to give context to a topic discussed in the curriculum, and to make classroom learning more closely approximate to what occurs in the work place. One problem to which attention needs to be given is that some students just copy into their presentations material from the Web without acknowledgment or use materials from other students. Refer also to Units A3, A6 and A7 in Appendix A.

Spreadsheets and Databases

In the social sciences, spreadsheets and databases serve a similar purpose, namely to enable students to systematize and organize information. For example, students can use a spreadsheet to make a list of dates, events, countries and persons involved. Such lists can then be organized by date, by country, or by a person's name and make effective study aids. Younger

students like to collect information and will enjoy setting up a database, for example, on facts about countries in their region. Refer also to Units A4 and A5 in Appendix A.

At a more advanced level, databases and spreadsheets can be designed by students themselves in order to help solve realistic and contextual problems (see Units E1 and E2 below in this module).

Social and Ethical Issues and Professions

Subjects in the social sciences provide opportunities to discuss ICT issues related to protection of privacy and attitudes towards protection of data and copyright. There is opportunity also for discussions on the impact of ICT in society (changing and new professions, unemployment, and the economic value of investing in ICT "dot.coms" and the so-called before and after new economy). Students can learn here to deal with problem issues like racism and violence, and they can obtain a better understanding of gender and intercultural issues. All these issues can be informed by appropriate use of the Internet (see also Unit A7 in Appendix A).

Statistics

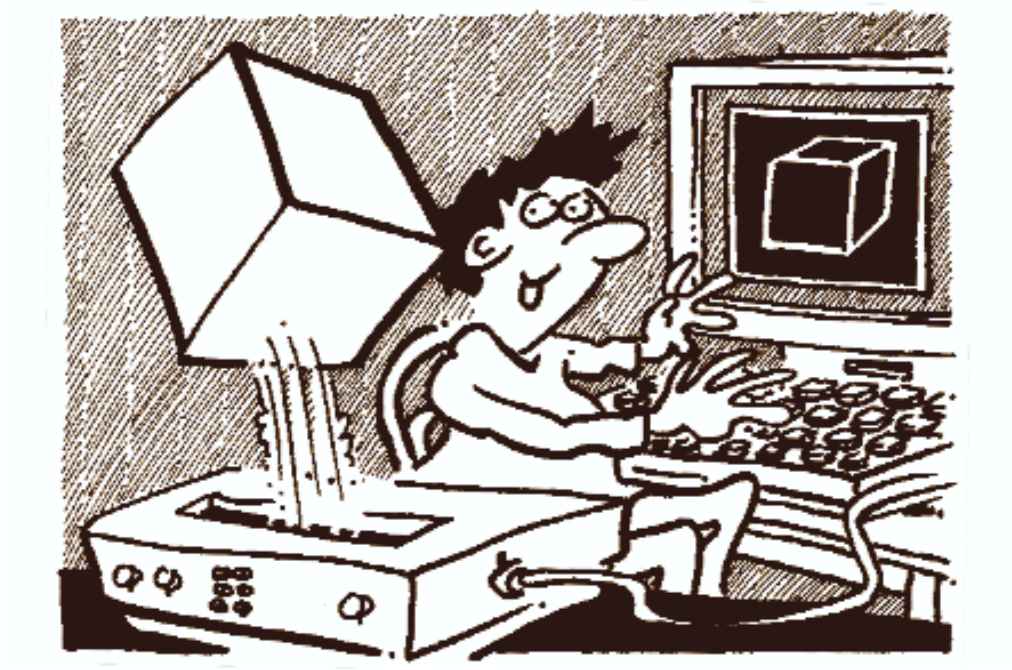
Especially in the study of geography at an advanced level, students may need to use a statistical package.

UNIT S5 – ICT IN ART

ICT can be used in numerous ways in subjects like art, music and dance. Here are just a few examples.

Creating Graphics

Some graphics packages (see Unit A6 in Appendix A and Unit B5 below) allow for the creation of original artwork. However, art teachers are often more interested in the way in which students can create patterns, complementary patterns, and patterns with variety. In textile design, for example, computers enable students to see an overall result with less effort than by any other method.



Students should be able to use computers in art

In the design of posters and other printed matter, the use of more sophisticated graphical software ensures a professional product in minimum time, with the option to re-use or modify a design at will.

Music

ICT can change the curriculum of music in many fascinating ways. Software tools give students the possibility of composing and performing musical arrangements themselves without having problems with technical aspects of notation or playing an instrument. Refer to Unit B6 below in this module for more detail.

Dance

In dance as in music, there is a range of easy-to-use software for designing simple choreographs to help students learn to perform.



Students should be able to use computers in dance and music

UNIT B1 – MEASUREMENT

Objectives

Students should be able to perform experiments where the measurement is done by computer and where the data can be processed and modified with ICT tools.

Sub-objectives

Students should be able to:

- know the system elements of an ICT measurement system: input (sensors), processor (computer), output (graphs, tables);
- perform simple computerized measurements on a practical experiment;
- process experimental data and draw conclusions from those data.

Context

Experimenting is one of the principal means to perform exploratory learning and to construct knowledge-based on experience. Some phenomena, however, cannot be experienced by normal "human" measurement, and need instead a computerized approach. Movement, for example, can be measured via a computer and then conclusions can be drawn from a series of measurements.

Content

A good introduction would be to demonstrate measurement in a laboratory experiment. The different parts of a measurement system can be introduced: input, processing, output. Students can work with the collected data using measurement software to create diagrams, perform calculations, and draw conclusions. At a later stage, they can perform the computerized measurement themselves.

Links

Unit A4 *Working with a Spreadsheet* (Appendix A).

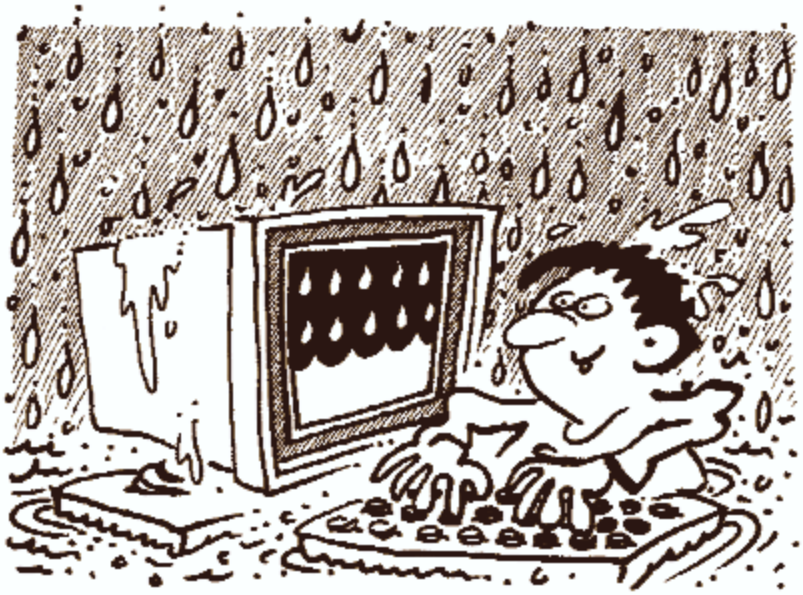
Methodology

Demonstration and later on practical work by students; data processing can be done by students, individually or in groups.

Resources

Minimum necessary resources	Optional extra resources
One computer per group of students. Measurement interface, and sensors. Specific software for measuring.	Software for analyzing video segments.

UNIT B2 – MODELLING AND SIMULATION



Students should be able to use computers for modelling and simulation

Objectives

Students should be able to identify the main parameters of a real situation, formalize a model, then explore it, interpret the results, and determine how the model fits with reality.

Sub-objectives

Students should be able to:

- use existing models (or mathematical functions), varying relevant parameters and interpreting results;
- modify an existing model (or mathematical function), varying relevant parameters and interpreting results;
- model situations with a small numbers of parameters, explore the model, and interpret the results.

Context

When teaching and explaining open phenomena in schools, presentations are often made in an excessively deductive way. To tackle, even at an elementary level, the modelling of a simple situation, allows one to balance deductive aspects with an exploratory approach (simulation versus modelling). This unit offers the opportunity to solve some true problems instead of "artificial" ones. Such experiences bridge the experimental and the theoretical (formal) approaches.

Content

A good introduction would be to simulate and experiment with an already solved problem (an existing model). Examples include radioactive decay, change in Ph-values, and population changes. Modifying an existing model, after running a simulation to try to understand the more important relations between the main parameters, helps to clarify the necessary basis for the real modelling process. Examples include supply and demand, pollution effects, and running a company. From concrete observations, very often visual ones, students can build up an outline of a system that allows them to reproduce the observed behaviour in an adequate way. Students can try out models on a spreadsheet or using a special modelling tool, if available.

Links

Unit A4 *Working with a Spreadsheet* (Appendix A).

This unit also links to the use of modelling in Units S1 *ICT in Natural Sciences*, S2 *ICT in Mathematics*, and S3 *ICT in Social Sciences* above in this module.

Methodology

Although many different approaches are possible, depending on the choice and availability of tools, it is essential when teaching this unit to limit oneself to simple models, even for complex situations.

Resources

Minimum necessary resources	Optional extra resources
One computer per group of students. Modelling software or a specific simulation program.	Existing commercial software, such as SimEarth, SimLife, and SimCity. Specific tools with graphical interfaces (e.g. Stella, Modus, Extend). Specific tools dealing with numeric and symbolic calculations (e.g. Mathematica, Derive, Mathlab, Mapple).

UNIT B3 – ROBOTS AND FEEDBACK DEVICES



Students should be able to operate a simple robot

Objectives

Students should be able to operate a simple robot and use a simple feedback device.

Sub-objectives

Students should be able to:

- control a specific robotic device;
- identify the situations where feedback devices are useful;
- use a simple feedback device.

Context

This unit links to industrial production in a country. The number of robots and feedback devices is increasing rapidly, with consequences for the labour market and qualifications demanded by employers. Students should have an understanding of the operation of robots since they are frequently and increasingly used in (a) dangerous situations, (b) improving the quality of the products, and (c) reducing labour costs.

Content

Students should use a simple software tool, or prepared user-interfaces, to control a robot. They should also attempt to build a simple robot device.

Students should use feedback devices in experiments in other subjects, such as a microphone in physics or a thermometer or Ph-meter in chemistry.

Links

Unit A1 *Basic Concepts of ICT* (Appendix A).

Methodology

Technical creative work for one or two groups, on a rotating basis.

Resources

Minimum necessary resources	Optional extra resources
A simple programmable robot device – with its own keypad or connected to a computer – for each group of students. A simple feedback device that provides input for a suitable computer program.	Suitable books, newspaper clippings of newly launched computer hardware or software, newspaper articles of soon-to-be launched or future hardware and software, videos, examples of hardware, software and peripherals.

UNIT B4 – STATISTICS

Objective

Students should be able to use a simple statistical package to the level required by other school subjects.

Sub-objectives

Students should be able to:

- call up the correct section of a statistical package and enter data;
- utilize output to the degree demanded by a particular subject.

Context

The teaching of statistics is not an objective of the ICT course. However, where students use statistics in other subjects, they should be able to handle a simple statistics program and produce output that they can interpret in context.

Content

This unit is likely to be used at the senior secondary level. Other subjects most likely to use the unit are economics, mathematics, agricultural science, biology and the social sciences. The complexity and volume of statistical work done will depend entirely on what is required by other school subjects.



Students should be able to use a simple statistical package

Links

Unit A4 *Working with a Spreadsheet* and Unit A6 *Composing Documents and Presentations* (Appendix A).

Many statistical packages allow importing of data from spreadsheets, and exporting of data to graphical packages.

Methodology

Any students who have made involved statistical calculations manually will always want to use a computer program for this purpose in the future.

Resources

Minimum necessary resources	Optional extra resources
One computer per group of students. Simple statistical program.	Training video or program.

UNIT B5 – CREATING GRAPHICS



Students should be able to use suitable graphics tools

Objective

Students should be able to use suitable graphics tools to create the graphics required for a variety of purposes.

Sub-objectives

Students should be able to:

- analyze a task and select the best graphics tool from the tools available;
- import drawings (graphics) from other sources, using a scanner if available;
- use graphics software to draw and animate drawings from other sources;
- produce attractive and suitable graphics-based materials.

Context

The world is visually based. It is important for students who wish to create visual materials to know how to use a computer and appropriate software to produce these materials.

Content

Students should know about the various graphics software tools available and be able to choose the most appropriate one for a particular task. They should be able to use software tools competently to create documents, including graphics for a variety of other school subjects.

Links

All units in this module.

Methodology

Demonstrations, hands-on experience, projects.

Resources

Minimum necessary resources	Optional extra resources
One computer per student, and graphics software.	Various input and output devices, samples of various computer-produced graphics-based materials.

UNIT B6 – MUSIC

Objective

Students should be able to create compositions, musical scores and arrangements of music as required in the subject, using appropriate hardware and software.



Students should be able to create and play music using hardware and software

Sub-objectives

To the level required in the subject Music, students should be able to:

- explore the use of appropriate hardware and software to play music, and to modify and print scores;
- demonstrate the use of appropriate hardware and software to compose musical pieces;
- demonstrate the use of appropriate hardware and software to arrange musical pieces.

Context

Available software enables musical scores to be written and edited with a computer in the same way that word processing packages are used for composing text. Music can be played back and listened to via suitable hardware. Students who are required to write musical scores should realize that the computer greatly facilitates this process. They should also know how to use appropriate software and take advantage of it for personal use.

Content

The teaching of music is not an objective of the ICT course. Before doing this unit, students should be able to identify the correlation between score and music. They should be able to modify an existing score in order to achieve a stated or desired effect. This ability should eventually be developed to the point where students compose original scores on a computer and arrange such compositions for different instruments, again using a computer.

Links

Units A1 and A3 (Appendix A).

Methodology

Hands-on experience.

Resources

Minimum necessary resources	Optional extra resources
Computer and music creation software.	MIDI interface and associated hardware.

UNIT E1 – SPREADSHEET DESIGN

Objective

Students should be able to design and create a spreadsheet to solve a given problem.

Sub-objectives

Students should be able to:

- identify problems that can be solved by use of a spreadsheet;

- enter headings of columns and rows;
- vary width of columns;
- allocate values to columns;
- create and copy formulas;
- re-arrange entries (rows);
- re-arrange columns;
- import information from a variety of sources;
- export information to a variety of destinations.

Context

The ability to create and use spreadsheets has become essential for all involved with financial management, with research, and in many other commercial activities. Spreadsheets have the advantage that most software programs can easily accept and manipulate information from databases and can create output as graphics. The ability to use spreadsheets efficiently is a distinct advantage when seeking employment.

Content

Creating a class hobbies list may be a good first exercise. Students should then create at least one spreadsheet to draw up a budget in which a number of "what if" situations arise. If the spreadsheet allows it, the reverse of this process should also be utilized. Students should create a simple spreadsheet to accept and calculate the results of an experiment or an opinion survey in at least one other subject. A number of spreadsheet applications will arise naturally in most school activities. Spreadsheets should be used to create lists that can be re-ordered as needed.

Links

This unit is an extension of Unit A4 W*orking with a Spreadsheet* (Appendix A).

Methodology

Collecting data, hands-on experience, and demonstration.

Resources

Minimum necessary resources	Optional extra resources
Computer for a group of students. Simple spreadsheet program.	Printer. Training video or computer program. Multimedia projector and overhead projector.

UNIT E2 – DATABASE DESIGN

Objective

Students should be able to create and use databases in a competent manner.

Sub-objectives

Students should be able to:

- understand some of the relevant steps in problem solving;
- identify problems that can be solved by a database;
- design and create a database;
- obtain data and enter these into a database;
- draw and interpret information from a database in a structured and rational manner;
- understand the principles of personal data protection.

Context

This unit extends the experience gained in studying Unit A5 *Working with a Database* (Appendix A). Familiarity with commercial databases is an advantage when seeking employment.

Content

Using a suitable example, students can design an appropriate questionnaire and collect data. They make a first structure of a database, and enter the

data. Some fields might be incorrect and therefore have to be modified. The database can be restructured until a usable database design has been established. During the process of using the database, students will become familiar with some of the main aspects of problem solving: design, data entry and modification, as well as with the use of the program. Principal data types such as text and number will be covered. If database systems with a programming language are available, principle elements of programming, such as conditions and loops, can also be considered. Analysis of the use of databases will demonstrate how commercial processes operate (for example, there would be serious problems for a new airline if it were not allowed to use the existing reservation system). Students should also be familiar with very large databases and Geographic Information Systems.

Links

This unit is an extension of Unit A5 *Working with a Database*. (Appendix A).

Methodology

Collecting data and hands-on experience.

Resources

Minimum necessary resources	Optional extra resources
One computer per group of students. Simple database programs. Some countries provide simple educational databases or special user interfaces for students at a reasonable price.	Advanced database programs. Multimedia projector and overhead projector.

APPENDIX C – INFUSING ICT ACROSS THE CURRICULUM

Contents

Examples of eight projects are described to demonstrate the use of ICT in a combination of subject areas in secondary schools where work is done on real-world projects and real problems are solved. Examples are given to show how, within one subject area, ICT can help students integrate several subjects such as, for example, mathematics, science, and art. Examples of larger projects are also provided that include several courses and several schools infusing ICT in community or global projects.

The curriculum examples provide guidance in how to plan your own project. The examples illustrate the use of ICT in different secondary school subjects with reference to curriculum units described in Appendix A.

A brief summary of each project follows with an accompanying web address for further details:

C1 Students write an additional "outside back cover" containing a summary of a book recently read with the purpose of motivating others to read it.

C2 Students study a current scientific theme. They then act as reporters and consult different people.

http://tecfa.unige.ch/~lombardf/YRE/projet_yre.html

C3 Students make weekly reports of an expedition and are able to communicate directly with the participants.

For similar collaborative projects, see http://www.en.eun.org/

C4 Students create multimedia software to aid them in learning a foreign language.

http:wwwedu.ge.ch/cptic/prospective/multimedia/allemand/welcome.html

similar: http://www.netdays2000.org/

C5 The mayor of our city has called together a task force to come up with a revised schedule of parking rates. Here are the four options of parking rates at the City Center Parking Garage. If you were on the city's governing board, which option would you choose and why?

http://www.apple.com/education/k12/leadership/acot/pdf/rpt11.pdf

similar:

http://www.apple.com/education/kl2/leadership/acot/ library.html

C6 Students investigate the 1920s decade, and then act as reporters, editors, and publishers.

http://wapiti.pvs.k12.nm.us/~Computer/jazzage.htm

similar: http://webquest/sdsu.edu/matrix.html

C7 The village is a micro-world representing a society in Canada in the last century. The project is a virtual community network started in 1987 involving teachers, students, parents, and historians.

http://prologue.educ.infinit.net/

C8 Students get the opportunity to explore problems that confront their community, and to work for solutions.

http://www.att.com/education/lcguide/sp/sp.html

similar: http://www.att.com/education/lcguide/p.intro/a.intro.html

An overview of the eight curriculum projects, the subject areas they cover, teaching methods, and links to curriculum units in Appendix A is shown in Table C.1.

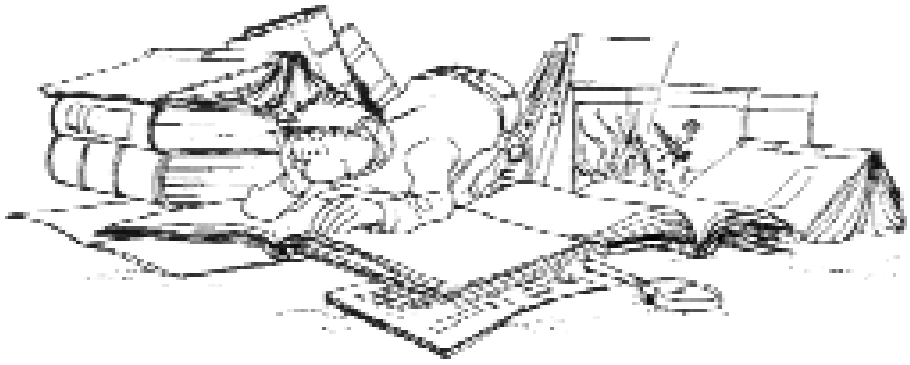
Table C.1 Eight ICT curriculum projects covering different subject areas together with teaching methods and links to curriculum units

No.	Project Title	Subject Areas	Teaching Methods	Units
C1	Encouragement to Reading	All subjects	Individual. Teamwork.	A1–A3, A5–A7
C2	Are We Becoming Genetically Modified?	Languages, Media, Biology, Chemistry, Economics	Teamwork and network of classes.	A1–A8
C3	Antarctica 2000	History, Biology, Chemistry, Social Sciences	Teamwork and network of classes.	A1–A8
C4	Multimedia and Languages	Languages, Media	Teamwork, differentiation, student-centred.	A1–A3, A6–A7
C5	The Parking Garage Problem	Mathematics, Economics, Social Sciences	Teamwork.	A1–A4, A6–A8
C6	The 1920s and its Excesses	Art, Music, History, Social Sciences	Teamwork.	A1–A3, A6–A8
C7	Le Village Prologue	History, Social Sciences, Media, Languages, Geography, Mathematics	Individuals. Classes. Teamwork. Virtual communication.	A1–A9
C8	Society's Problems	Social Sciences, Citizenship and related subjects	Teamwork and network of classes.	A1–A8

UNIT C1 – ENCOURAGEMENT TO READING

Objective

To help meet some of the *Computer Literacy* objectives (see *ICT Literacy* in Appendix A), and link students and teachers in school with information scientists and librarians.



Linking students with books

The project

Students write an additional outside back cover for a book that summarizes one they have recently read. The purpose is to motivate fellow students to read the book, not a marketing exercise.

Preparing the summary

Students use a word processor to prepare the text summary, adding information about the readers to whom this book should appeal, as well as keywords, ISBN number, and an abstract that could be used by school or local libraries. A complementary activity could be to make an award for a book of the month selection.

Database creation

Students collect contributions from other students in the same or different classes or schools within their region to create a database of reviewed books.

Database use

Students interrogate the database for their next reading choice, to find or order a book from the librarian, or to link with the database of the school documentation centre.

Source: *Informatics for Secondary Education: A Curriculum for Schools*, UNESCO, Paris, 1994.

UNIT C2 – ARE WE BECOMING GENETICALLY MODIFIED?

The project

Students study a current scientific theme. They act as reporters and consult different people. Then they present the results to the class and discuss the different opinions to form their own view about the topic.

Working methods

All the work is done by students. The teacher takes the role of co-ordinator, animator and adviser. Participants are students working in groups, classes in different countries.

Biology

Students use a collection of Internet addresses and libraries to find and retrieve information that they can use for their work.

Databases

Students learn to evaluate information found on the Internet and they practise searching strategies.

Presentations

Students learn to present the findings in a scientific way, that is, quoting from sources and citing references.

Languages

Students practise writing for newspapers. They also exchange emails in foreign languages.

Source: *Young Reporters of the Environment*

http://tecfa.unige.ch/~lombardf/YRE/projet_yre.html

UNIT C3 – ANTARCTICA 2000

The project

In November 2000, Ann Bancroft (USA) and Liv Amesen (Norway) flew to Antarctica accompanied by nothing more than their skis, two sleds, and enough food and equipment to sustain them during their 100-day, 2,400-mile (3,850 km) trek across the frozen continent. After completing the traverse in February 2001, they were the first all-women's team to cross Antarctica.

A group of students at Melladammen, Norway, made weekly reports from the expedition and were able to communicate directly with Ann and Liv in Antarctica as well as integrate the project in the overall teaching activities of their class.

History

Students inquire about former expeditions in libraries and on the Internet.

Biology

Students learn about health and nutrition. They create a spreadsheet about the amount of food needed compared to the miles walked.

Chemistry

Students learn about pollution and the consequences for the ozone hole.

Geography

Students study meteorology and consult existing databases. They create a database for the duration of the expedition.

Sociology

Students study their own dreams. They exchange email with other students and discuss the dreams other people have.

Source: *Antarctic Polar Challenges*. Although this particular web page is no longer available, you can find other similar collaborative projects on European Schoolnet (http://www.en.eun.org/).

UNIT C4 – MULTIMEDIA AND LANGUAGES

The project

Students create their own multimedia software to help in their learning of a foreign language.

Working methods

Teamwork, differentiation, in student-centred work.

Language

Students learn the language in a playful way.

Composing documents and presentations

Students learn to present their work in a screen/software environment.

Source: *Students, language and multimedia*

http://wwwedu.ge.ch/cptic/prospective/multimedia/allemand/welcome.html

More to be found at Netd@ys (http://www.netdays2001.org/)

UNIT C5 – THE PARKING GARAGE PROBLEM

The Project

Suppose that the mayor of your city, in an effort to encourage shopping at the new downtown City Centre, has called together a task force to come up with a revised schedule of parking rates. He gives you the four options below of parking rates at the City Centre parking garage. If you were on the city's governing board, which option would you choose and why?

Option I

Pay 35 cents for up to, but not including, the first hour. Pay an additional 50 cents for up to, but not including, the second hour. Pay an additional 50 cents for up to, but not including, the third hour, and so on.

Option II

Pay 10 cents for up to, but not including, the first hour. Pay an additional 50 cents for up to, but not including, each additional hour.

Option III

Pay 35 cents for up to, but not including, the first half hour. Pay an additional 25 cents for up to, but not including, each additional half hour.

Option IV

Up to the first hour is free. Pay 75 cents for each additional hour.

The long-term goal of this project is to develop an instructional model for mathematics-based on a constructivist framework.

Mathematics

Students create a simulation of a parking garage.

Economics

Students discuss the economic outcomes of the different options.

Social science

Students learn to make decisions and to consider the impact of these.

Source: *Apple Classrooms of Tomorrow: Research*

http://www.apple.com/education/k12/leadership/acot/pdf/rpt11.pdf

More to be found in the ACOT Library

http://www.apple.com/education/k12/leadership/acot/library.html

UNIT C6 – THE 1920s AND ITS EXCESSES

The project

The 1920s in the United States was a period of opulence and excess that led to the inevitable consequences of the 1930s and the Great Depression. Our romantic image of the Jazz Age (Roaring Twenties) is heightened by the images of flappers, pin striped suits, Model T Fords, the Charleston, Prohibition, and Speak Easies.

Method

Students act in groups of two in the role of reporters/editors/publishers from the 1920s.

Art

Students inquire about fashion, architecture and literature.

Music

Students learn about the culture of jazz.

History

Students gather information using given URLs.

Social science

Students discuss social implications.

Writing

Students create newspaper articles describing the roaring 20's using desktop publishing programs. Then they give oral presentations based on their articles.

Source: *The 1920s and its Excesses: A Web Quest*

http://wapiti.pvs.k12.nm.us/~Computer/jazzage.htm

More to be found in Web Quest http://webquest.sdsu.edu/matrix.html

UNIT C7 – LE VILLAGE PROLOGUE

The project

The village is a micro-world representing a society in Canada in the last century. It is a virtual community network started in 1987 involving teachers, students, parents, historians, and others. Users can discuss subjects with virtual persons solving problems from that time.

Methods

Individual work, teamwork and network of classes.

History

As a result of communicating by email with persons from the past century, students learn about history.

Language

Students practise their own language and get the opportunity to communicate in foreign languages.

Social sciences

Students try to solve problems people had in former times.

Writing and Reading

Students use a text processing program to write stories, poems and biographies about historical personalities.

Communication

Students become familiar with communicating in a virtual world.

Source: *Le Village Prologue*
http://prologue.educ.infinit.net/

UNIT C8 – SOCIETY'S PROBLEMS

The project

Students get the opportunity to explore problems that confront their community and to work for solutions.

Methods

Teamwork and network of classes.

Communication

Students use email or real contacts to exchange information with other classes and with residents.

Social science

Students learn about citizenship related to school subjects.

Source: *Mind Works Learning Circles*
http://www.att.com/education/lcguide/sp/sp.html

More to be found in *Learning Circles*
http://www.att.com/education/lcguide/p.intro/a.intro.html

APPENDIX D – ICT SPECIALIZATION

Contents

Specialization Preparation Module

SP1 Introduction to Programming
SP2 Top-Down Program Design

General Specialization Module

GS1 Foundations of Programming and Software Development
GS2 Advanced Elements of Programming

Vocational Specialization Module

VS1 Business Information Systems
VS2 Process Control Systems
VS3 Project Management

The units described in this appendix are designed for students who plan to go into professions that use ICT such as engineering, business, and computer science, or who plan to advance to higher education. These units cover the use of advanced tools and techniques for ICT specialists. Topics include basic and advancing programming, planning information systems, designing process control systems, and project management.

SPECIALIZATION PREPARATION MODULE

Objective

Students should be able to solve routine everyday problems in an algorithmic form.

Context

The word algorithm is to be interpreted in its broadest sense, avoiding a narrow mathematical definition. Depending on the local situation and the availability of resources, the objective can be met either by including units SP1 and SP2, or by stressing the problem-solving nature of using software tools as addressed in the *ICT Literacy* module (Appendix A), thus avoiding too formal a treatment of algorithms at this stage.

Prerequisites

Units Al to A5 (Appendix A)

Structure

Unit SP1 *Introduction to Programming*
Unit SP2 *Top-Down Program Design*

Unit SP1 – Introduction to Programming

Overall Objective of the Unit

Students should be able to design, program, and evaluate simple algorithms for elementary task-oriented problems (the term **algorithm** being interpreted in its broadest sense).

Context

Programming at this level is not a technical subject. By and large, it means changing a task you can "do for your yourself" into one which can be "done by others". This means describing a task as a procedure in suf-

ficient and complete detail so that another person or a device can perform it precisely and repetitively.

This "automation" of a task is what is called programming, sometimes algorithmic programming – one of the main features of informatics. An algorithmic way of thinking and problem solving is needed when using complex or sophisticated tools such as a spreadsheet, a database management system, an operating system, or even a word processor.

Programming is a rapid, specific, and suitable way for students to gain experience of solving problems. The objective is not to train "mini-programmers", but to bring students in contact with how programmers think. With this aim in mind, the syntactical and other specific features of a programming language are of little importance and have only to be learned on a "need-to-know" basis. Teachers should stress the methodological aspects of problem solving: programming is just a means to an end, rather than a goal in itself.

Summary of Content of Unit

The unit contains three main activities: designing a task-oriented algorithm (algorithmic problem solving), translating the design into a program (programming), and bringing the program to life (implementation). These three activities will always be successive and closely tied together. Although the following descriptions treat each activity separately, the order of presentation does not necessarily dictate the order of teaching.

1. Designing a Task-Oriented Algorithm (Algorithmic Problem Solving)

Objectives

Students should be able to:

- describe and specify the task to be realized;
- develop an effective and efficient algorithm that realizes the identified task, applying a simple, given standard method.

Content

Students have to experiment and identify the steps involved in the process of problem solving, applying simple problem solving strategies in a given format to specify solutions to simple problems drawn from their everyday lives. Examples of suitable problems are simple simulations of dice throwing, tossing of coins, calculations such as the formulas for areas and volumes, or the interest on money loans and deposits, turtle movements in a plane.

When students have built up some expertise, they should learn to sub-divide the tasks to be automated into major sub-tasks and into fundamental tasks, which are given suitable, meaningful names.

2. Translating the Design into a Program (Programming)

Objectives

Students should be able to:

- transform their simple algorithms into computer programs using a (procedural) language;
- produce a readable, understandable and user-interactive program.

Content

Teachers should choose simple problems that only require students to use elementary input, output, and assignment operations of a programming language. Where applicable, students should determine proper types and uses of variables; and select suitable and meaningful variable names that represent the functions of the variables in the program.

Examples of possible programming environments are Visual Basic, Pascal, Java Script, or an environment for controlling a physical device (e.g. a robot).

Students should not be forced to use a separate editor or text processor for entering their programs.

3. Bringing the Program to Life (Implementation)

Objectives

Students should be able to:

- use a given programming environment to enter, edit, compile, debug, update, and run programs they construct;
- give a meaningful and useful written description of the internal and external behaviour of their program.

Content

Students should store and retrieve programs on and from disks, for further use and modification. They should learn to differentiate between syntax errors and execution errors; and identify possible causes for each type of error. Students should test their programs with given or created test data to determine correctness and limitations, and they should learn how to obtain printed output and a hard copy of source code.

Teachers should ensure that clear and adequate documentation is produced of all programs so that other users can understand the operation of the programs and make further modifications.

Resources

Minimum necessary resources	Optional extra resources
One computer between two students (one may plan while the other enters code or tests).	A simple programming language, preferably with a graphical interface.

Links

This unit, together with Unit SP2, are essential preparation for the *General* and *Vocational Specialization* units.

Unit SP2 – Top-Down Program Design

Overall Objective of the Unit

Students should be able to design, program, and evaluate structured algorithms for problems that need a top-down approach.

Context

After initial experiences with simple algorithmic design and programming in Unit SP1 *Introduction to Programming*, students should learn to use a top-down approach, while using the same design tools and programming environment. When problems become more complex, the need for a top-down approach is more evident. Top-down programming is the normal way that commercial software is designed and produced.

Summary of Content of Unit

The unit contains three main activities: top-down design of algorithms, translating the design into a program, and bringing the program to life. As with Unit SP1 Introduction to Programming, these three activities will always be successive and closely tied together. Although the following descriptions treat each activity separately, the order of presentation does not necessarily dictate the order of teaching.

1. Top-Down Design of Algorithms

Objectives

Students should be able to:

- describe and specify the problem to solve;
- develop effective and efficient algorithms for the solution of a problem, using a top-down approach through step-wise refinement.

Content

At first, the teacher sets some complex problems to be solved, but in the context of ready-made procedures already built and available in the system (and corresponding to parts or sub-problems of the original problem). At a second stage, these procedures will be analyzed by students, and they will now also construct these procedures themselves.

Some problems should address the processing of strings, using the tools offered by the available programming language. Algorithms of this type are important because they make it evident that only formal processing is to be expected from a computer. Examples of suitable problems are: concatenation, counting the number of words in a text, writing a text in reverse, changing all the vowels in a text, searching for a word in a text.

It is important to point out problems that fall outside the scope of these formal possibilities, such as translating a text, correcting a text, or summarizing a text.

2. Translating the Design into a Program

Objectives

Students should be able to:

- understand that a computer processes "formal objects" only;
- transform their algorithms into computer programs in a procedural language using formal procedures or functions;
- produce a procedure-structured, readable, understandable, and user-interactive program.

Content

It is important that the top-down designed algorithms are transformed into programs that have procedures and functions, so that students appreciate the need for these constructs.

Before any actual program is written, students should evaluate and debug, step by step, a given, subdivided algorithm; they should create

their own set of test data and explore the different parts of the algorithm, but also the algorithm as a whole.

Students should use the following programming constructs: procedure, function, global and local variables, parameters. They should be offered procedures and functions as tools for string processing that they will use to solve text processing problems.

3. Bringing the Program to Life

Objectives

Students should be able to:

- use a standard programming environment to edit, compile, debug, update, and run constructed programs;
- give a meaningful and useful written description of the internal and external working of the programs.

Content

Students should store and retrieve programs on and from disks, for further use and modification. They should learn to differentiate between syntax errors and execution errors; and identify possible causes for each type of error.

Students should test their programs with given or created test data to determine correctness and limitations, and they should learn how to obtain printed output and a hard copy of source code.

Teachers should ensure that clear and adequate documentation is produced of all programs so that other users are able to understand the operation of the programs and make further modifications.

Resources

Minimum necessary resources	Optional extra resources
One computer per student; and a suitable programming language or tool.	Printer; multimedia projector and overhead projector.

Links

This unit is essential preparation for the *General* and *Vocational Specialization* units.

GENERAL SPECIALIZATION MODULE

This specialization module is specified for secondary schools that have the necessary hardware and software, as well as trained teachers able to deliver the units.

Ideally, courses should be built up from Units GS1 and GS2, in consultation with universities and tertiary institutions, so that advanced credit can be obtained towards a tertiary computer science course.

Objective

Students should be able to design and implement technical computer-based systems that model real problems using an algorithmic, problem-solving approach.

Context

Units GS1 and GS2 together represent a standard set of courses that are commonly used at both secondary and post-secondary level as a foundation in the study of informatics. The depth and breadth of coverage and practice must be adjusted to match the student population so that students will be able to enter higher education with basic knowledge and skills in the programming of systems and in software development.

Prerequisites

Units SP1 and SP2.

Structure

Unit GS1 precedes Unit GS2.

Unit GS1 – Foundations of Programming and Software Development

Objective

Students should be able to design and program relatively small computer-based systems that model process-oriented problems.

Sub-objectives

Students should be able to:

- adhere to the basic principles of software engineering;
- methodically analyze procedure-oriented problems through decomposition into procedural steps;
- apply more or less formal techniques to design effective algorithms and data structures;
- code and realize programs and sub-programs (modules) using a general purpose programming environment;
- use a functional model of a computer system and its programming environment.

Context

Students need to develop skills that are fundamental to informatics as a discipline and to software development at all levels. These skills include the use of more or less formal methods of problem analysis and program design with an emphasis on creating not-too-complex programs that meet given specifications, and which contain usable user interfaces.

Specific attention is paid to the type of problems that can programmed using fundamental, simple and structured data types (character, integer, real, and array) and basic control structures (sequence, selection, and repetition) of a high-level, block-structured programming language.

Emphasis is on modelling through process abstraction (top-down decomposition into sub-processes and sub-programs). Methods of analysis, design strategies, and the programming language environment should support this type of modelling.

Content

Students will solve several, increasingly complex problems. Problems are drawn from real application areas that students can readily understand and model. Small individual problems are chosen to learn how to use new algorithmic operations in conjunction with elements already known. But, in addition, some all-encompassing problems should be included in which students have to integrate all that they have learned before.

Problem Analysis

Students apply informal and elementary formal techniques to analyze simple process-oriented problems in many application areas and describe them in terms of sub-process steps.

Design

Algorithms: Students design modular solutions through top-down analysis and stepwise refinement. They choose and specify data structures and algorithms to match the design. The data structures and control structures used in the algorithms should be directly related to the primitive structures of a block-structured programming language.

User Interface: Students design a simple user interface for their algorithms in the form of a tree of screen designs.

Programming

The algorithms and the modular structure are coded into a general-purpose programming language.

Realization and Evaluation

The code is then realized in the form of a program running on a computing system making use of the available programming environment. Students need to test and debug the programs and identify the limitations of the programs.

Topics

Software Engineering

Problem solving process, software life cycle.

Analysis

Process, input and output specification.
Identification of steps and modules.
Informal specification of pre- and post- conditions.

Design

Top-down, modular stepwise refinement.
Simple, useful user interfaces.

Algorithms

Simple and nested control structures.
Simple data structures.
Code structure, readable and useful form.
Elementary sorting and searching algorithms.
Simple recursion.
Design of test data.

Realization

Execution, testing, and debugging.
Documentation.
Bottom-up testing.
Incremental realization.

Evaluation

Informal comparison of algorithms.
Limitations of design and program.

Programming Environment

Hardware components.
System software and compilers.
Representation of stored data.

Programming Language Elements

Simple and structured data types of language, user-defined types.
Evaluation of expressions and standard elementary library functions.
Sequence, control, and iteration structures.
Simple interactive and text file input and output.
Sub-programs and parameters.
Local and global variables and scope of variables and subprograms.

Resources

Minimum necessary resources	Optional extra resources
Version of a high-level block-structured programming language that supports modular program design and contains the necessary data types and control structures. Introductory level textbook that presents examples of applications using the programming language. Most relatively recent texts on an introduction to informatics or on computer science organizational patterns, which have been developed through practice, fit the objectives of this unit.	Additional text material on machine organization, systems software, compilers and language translators, internal representation of information, software engineering and the software life cycle.

Links

SP1 Introduction to Programming
SP2 Top-Down Programming
VS1 Business Information Systems

Methodology

The concepts and skills included in this unit are those that have usually been presented in a first course on informatics for advanced students, which some countries will find more appropriate for tertiary institutions than for secondary schools. The unit is quite extensive and requires teaching time every week, extending from over half a year to more than one year. The time needed depends on prior experience and student background: whether they have studied Computer Literacy or Programming at Foundation Level. Depending on the target group, a sub-division of the unit may be advisable, organized around the concepts or principles under study.

Emphasis in the unit must be placed on hands-on applications. Students must apply techniques and principles, starting with elementary problems and building up their ability to handle more complex problems. Skills and concepts learned in earlier lessons are constantly reinforced through practice in new problems involving new concepts. Periodic exercises and projects that allow students to synthesize and integrate what they have learned must also be included.

Unit GS2 – Advanced Elements of Programming

Objective

Students should be able to design, program and evaluate relatively complex computer-based systems that model process-oriented problems in many subject and application areas.

Sub-objectives

Students should be able to:

- methodically analyze and model relatively complex process-oriented problems in a variety of application areas;
- apply moderately advanced formal analysis, design and data abstraction techniques to design effective algorithms, abstract data types and relatively sophisticated data structures;
- code and realize programs and sub-programs (modules) using a general purpose programming environment;
- evaluate and explore alternative designs to programs.

Context

Students should develop skills for solving more complex and sophisticated problems in many application areas. Emphazis needs to be placed on model-ling through data abstraction (an important technique for improving reliability and re-use). Specific attention should be paid to algorithms and strategies for simulating advanced linear and non-linear data structures for the implementation of abstract data types.

Content

This unit extends and builds on unit GS1 *Foundations of Programming and Software Development*. Students will solve several, increasingly complex problems from real application areas.

Problem Analysis

Students develop models for relatively complex process-oriented systems using design strategies, such as modelling through abstract data types. They analyze systems to determine basic data objects, and associated functions that are used on these objects in the system.

Design

Students develop abstract data types for the identified objects, which may be re-used in other designs that involve the same objects. Students design a solution for the problem expressed in terms of modules that manipulate the abstract data objects only through the identified functions. Students design a suitable and effective user interface.

Programming

Students construct sophisticated linear and tree-like data structures to represent the abstract data types and also construct the functions needed to access these abstract data types in a general purpose programming language that supports information hiding and encapsulation, either directly or through simulation of data abstractions. Students code their design in the programming language.

Realization

The coded programs are realized and run in the programming environment. Students first realize, test and verify the realization of the abstract data types, and only then the entire program.

Evaluation

Students determine order of magnitude indicators to compare algorithms, and practise some basic formal methods of program verification.

Alternative approaches

Where time is available, design strategies using other development paradigms, such as object-oriented methodology or logic programming, may be explored if resources make this possible.

Topics

Software engineering

Design for reliability, reuse.

Analysis

Analysis strategies, such as data flow analysis using pre- and post- conditions. Formal program verification, assertions, invariants.

Design

Data abstraction and information hiding.
Effective user interfaces.

Algorithms

Graphs and graph algorithms.
Encapsulation of abstract data types.
Dynamic data types and structures.
Binary trees.
Binary search trees.
Advanced searching algorithms.
Efficient non-quadratic sorting algorithms.
Hashing methods.

Evaluation

Algorithm analysis for order of magnitude approximation.
Limitations of algorithms and unsolvable problems.
Limits of numerical representations and simple numerical methods.

Programming Language Elements

Singly and doubly linked list representations.
Stacks and queues.
Non-linear table data structures.

Optional

Applications in graphics, robotics, or artificial intelligence.
Modelling using logic or functional programming.
Object-oriented programming.
Parallel processing of algorithms.

Resources

Minimum necessary resources	Optional extra resources
A high-level, structured programming language environment that supports modular program design and data abstraction. Intermediate level, modem textbook on data structures and algorithm analysis that uses a data abstraction approach.	Programming environments for logic, functional, object-oriented programming or parallel processing.

Links

Unit GS1 *Foundations of Programming and Software Development*

Methodology

Emphasis is on concepts, theories, and practices of the discipline rather than on exhaustive coverage of language syntax. It is advisable to use, if possible, the same structured programming language for both units. The unit has an established traditional content that is described in many advanced texts on data structures. Teachers and curriculum designers

should consider using the structure of these texts as the basis for sub-units and curriculum development.

VOCATIONAL SPECIALIZATION MODULE

Objective

Students should be able to design methodically, realize and implement relatively simple information systems with the aid of problem-oriented tools, and identify problems involved in project management.

Context

Units VS1, VS2 and VS3 together prepare students for a start in a business environment where ICT plays an important role. Unit VS1 addresses the problem of the design, realization and implementation of a simple (business) information system for administrative purposes. Unit VS2 addresses the problem of the design, realization and implementation of a simple technical process control system for technical purposes. Unit VS3 addresses the issues of project management involved.

A higher technical level of competence can be achieved by studying Unit GS1 from the *General Specialization* Module before starting on VS1, VS2 and VS3.

Instead of studying Units VS1, VS2 and VS3 in sequence, Unit VS3 may be used to provide a realistic context within which the objectives of Units VS1 and VS2 can be met.

Prerequisites

Unit SP1 and Unit SP2; or Unit GS1.

Structure

Unit VS1 and Unit VS2 in combination with Unit VS3.

UNIT VS1 – BUSINESS INFORMATION SYSTEMS

This unit assumes basic competence in the use of computer systems and programming skills as developed in the *Specialization Preparation* Module.

Overall Objective of the Unit

Students should be able methodically to plan, design, realize and implement relatively simple information systems with the aid of problem-oriented tools.

1. Information Planning

Objective

Students should be able to use formal methods of data flow analysis to identify requirements for an existing information system.

Context

Students should be able to relate programming to the real world, and especially the world in which they are likely to find employment. The relevance of the material will enhance the value of the course and make it more interesting for both student and teacher.

Content

Students will analyze a simple case study of, for example, a warehouse or an accounting office, which is described in such a way as to provide the necessary information. The case study will be so constructed that no advanced use of techniques is required. The techniques used will be based on diagrams.

Students will work in groups using different methods to collect data such as interviews and questionnaires. The forms and other documents used in the case study of an organization will be analyzed as sources of accurate information.

The following student activities are part of *Information Planning* phase of the unit:

- sketch the data flow within a given organization;
- quantify the volume of data flowing in the organization;
- assess the speed of data flow within the organization;
- specify a relational data model;
- identify functions to be provided to employees by the information system.

2. Design

Objective

Students will be able to develop a design of a simple database and a limited number of associated functions for data entry, data retrieval, data updating, and data presentation.

Context

The case study should only require a few functions to be specified and the required human-computer interface will be of a simple, standard form. The teacher could play the collective role of the users.

Content

In designing a database, students will need to be accurate by specifying the overall structure and the specific details for the variables in relation to the data to be used. It will be necessary to review specifications with users to ensure that the specifications are comprehensive and appropriate.

The following student activities are part of the *Design* phase of this unit:

a) specify the structure of the database;

b) specify sample data to be included in the database;

c) specify the necessary functions and the human-computer interface;

d) design a small program in terms of the database, the functions and the interface.

3. Realization

Objective

Students should be able to realize and test the designed program on a computer.

Context

Students will typically use a programmable database system from an Office Suite or a structured, general purpose programming language with a comprehensive library of pre-programmed database functions.

Content

Before trial-running the program with test data, students will need to establish criteria to be used in the evaluation, testing of specifications, and coding. Proper documentation will be necessary to enable students to trace the sources of errors.

The following student activities are part of the *Realization* phase of this unit:

a) transform the designed program into a real program;
b) specify testing criteria for the program;
c) trial-run the program with test data;
d) test and verify the coding;
e) identify problems areas and provide solutions.

4. Implementation into the Organization

Objective

Students should develop a feeling for the problems associated with the implementation of an information system into an organization.

Context

Students could play the different employee functions in the case study of the organization, while the teacher could supervise the role-playing, and help in identifying any problems.

Content

Students will have their design, and specifications of their program validated with respect to the real-life situation. They will categorize the nature of the problems into classes: data model, specification, functions and interface. The teacher will bring their attention to the importance of documentation.

The following student activities are part of the *Implementation* phase of this unit:

a) implement the information system into the role-played organization;
b) identify problems with the use of the system;
c) suggest practical solutions to any problems identified.

5. Use in Organization

Objective

Students should be able to evaluate the effectiveness of the running of their program within the organization.

Context

Students will run the system simulating the organization involved. The technical skills of students will be put to the test by this life-like environment, thus providing students with an opportunity to evaluate their ability to identify the capabilities and limitations of their system.

Content

Using data specifications, students will evaluate the capabilities and limitations of their system. Software and hardware interface errors will have to be corrected, enhancing the design.

The following student activities are part of the *Use in Organization* phase of this unit:

a) monitor the effectiveness and efficiency of the system;

b) evaluate the capabilities and limitations of the system to handle the activities in the organization.

Resources

Documentation from previously developed systems should be made available to students.

Although it is likely to be aimed at tertiary students, a relevant book on Systems Development would be helpful as background material.

A programmable database system like dBase or a structured, general purpose programming language with a comprehensive library of pre-programmed database functions should also be available to students.

Links

Unit A5 *Working with a Database*
Unit E2 *Database Design*

UNIT VS2 – PROCESS CONTROL SYSTEMS

This unit assumes basic competence in the use of computer systems and programming skills as developed in the *Specialization Preparation* Module.

Objective

Students should be able methodically to plan, design, realize, and implement relatively simple process control systems with the aid of problem-oriented tools.

1. Planning of Process Control

Objective

Students should be able to identify requirements for technical systems that control or automate processes within some environment.

Context

Students will develop an awareness of the various functions of control systems needed to monitor technical systems within organizations. After that, they will work on a case study connected with a simple process to control, such as a robot.

Content

The following student activities are part of the *Planning* phase of this unit:

a) use existing control systems to monitor technical systems;
b) specify problems within a given technical environment;
c) identify the need for technical process control within the given environment;
d) identify the input and output data that are needed to control the system under consideration;
e) specify the functions needed to control the system under consideration.

2. System Design

Objective

Students should be able to design simple systems that control and monitor technical processes.

Context

In preparation for the world of employment, students should be able to analyze a simple case study connected with a simple device, such as a robot. They should also be able to design and enhance the technical operations of the control system.

Content

Using a case study, students will develop techniques to write a program to support an existing system for efficient operations. The case study will be limited to the use of simple sequential procedural algorithms.

The following student activities are part of the *System Design* phase of this unit:

a) produce technical specifications of the procedures needed;
b) design the procedures of the controlling system.

3. Realization

Objective

Students should be able to program simple procedures for process control.

Context

Students should be able to translate the designed procedures into a program for a problem-oriented programming environment (for example a language for robot control), or for a general purpose programming language with a comprehensive library of pre-programmed control procedures.

Content

The following student activities are part of the *Realization* phase of this unit:

a) realize small programs designed to support control operations;
b) specify testing criteria for the program;
c) trial-run the program for testing purposes;
d) test and verify the coding;
e) identify problems areas and provide solutions.

4. Implementation into the Environment

Objective

Students should develop an appreciation for the problems associated with implementation of a control system into the (organizational or technical) environment.

Sub-objectives

Students should be able to:

- identify any technical problems associated with the implementation of the control system program;
- classify any problems relating to the software and hardware interfaces.

Context

Using a real-life, case study environment, students should be able to evaluate and validate the specification, design, and coding of their program. For example, the controlled robot could be part of a production line and students can simulate the operation of the production line.

Content

Students will have their design and specifications of their program validated with respect to a real-life situation. They will categorize the nature of any problems into classes: data, specification, control functions and interface. The teacher will bring their attention to the importance of documentation.

The following student activities are part of the *Implementation* phase of this unit:

a) implement the controlled system into the role-played environment;

b) identify problems with the use of the system;

c) suggest practical solutions to any problems identified.

UNIT VS3 – PROJECT MANAGEMENT

Objective

Students should be aware of the main variables that influence the progress and success of a project, and they should be able to plan team activities within a given, but not-too-long, timeframe.

Sub-objectives

Students should be able to:

- identify the goals of a project and all the variables (social, political, financial, economic, cultural and human resources) that are likely to affect the implementation of the project;
- plan team activities and use a simple graphical planning tool.

1. Planning Phase of a Project

Objective

Students should be able to identify the objectives of a project and have an appreciation of the variables that may affect successful implementation.

Context

Team work is essential in the modern information technology environment. Students should work on a project as a team in the *Planning* phase (see also Units VS1 and VS2). Students should understand and appreciate their respective roles as members of the team.

Content

The objectives and parameters of the project have to be defined to ensure that all the variables will be considered at the appropriate stages of the project. Students will be made aware that market research should be undertaken to ensure that decisions affecting the project will be based on quality information.

Sub-objectives

As part of the planning process, students should be able to:

- identify the objectives of the project to be implemented;
- state the objectives in operational terms;

- identify the social, cultural, political, financial, and human resources variables that may influence the project.

2. Design Phase and Realization Phase of the Project

Objective

Students should be able to plan team activities and use a simple graphical planning tool.

Context

In the real world, having the best plans means nothing if you cannot "sell" them within an organization. Students should give a mock presentation of their project in their respective teams while another team evaluates their plan, pointing out what they see as problems and asking the team presenting to justify their choices and strategies of the suggested way forward.

Content

The following student activities are part of the *Design* phase and *Realization* phase:

a) identify all the essential output from the project;
b) quantify the output in terms of time, materials, financial and human resources;
c) plan the application of resources with a simple graphical planning tool.

3. Implementation Phase of the Project

Objective

Students should be able to relate the quality of the outcome of a project to the *Planning* and *Realization* phases, and to the monitoring of the project during these two phases.

Context

In the real world, we learn and make progress by analysing the good and the bad points of every project, planning to re-utilize the good and avoid the bad in future. Students should discuss, under the directions of the teacher, how each of the identified variables has affected the implementation of the project and what should be done to minimize negative effects. Each team presents a comprehensive picture of what they propose should be done.

Content

The following student activities are part of the *Implementation* phase:

a) collect data relevant to the quality of implementing the project;
b) identify factors that have adversely influenced the project;
c) suggest ways to improve the management of the project.

Information and communication technology (ICT) has become, within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education, alongside reading, writing and numeracy.

This book deals with ICT in secondary schools, and with the changing competencies required of both students and teachers if they are to function effectively in today's society. It specifies an ICT curriculum for secondary schools, and outlines an accompanying programme of teacher development to implement such a curriculum.

