ICT Integration in Biology 2

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I. ICT Integration In biology

By Mamadou Sarr and Salomon Tchameni Ngamo

II. Prerequisite

ICT basic Skills
Access to a computer
Access to Internet* (highly recommended for many activities)

III. Time

120 hrs (40hrs. focusing on general teaching skills in the use of ICTs in education; 80 hrs specific to the use of ICT in biology)

IV. Material

Computers, CD-ROMs, software simulation, animation

V. Module rationale

Excellence in education calls for the integration of various media, technologies and techniques to teaching and learning environment. Access to a new generation of ICT has brought new opportunities to teachers and learners in the sciences. However the effective integration of such applications depends on educator’s familiarity with and command of the new resources. A module on the integration of ICT in the science classroom is therefore a valuable addition to progressive science and mathematics educators’ progressive development.

VI. Content

The process of integrating ICT in education is rarely a simple and linear one - overlaps are often noted, with some elements operating in parallel, in partnership and cyclically. The sequence of steps varies from one activity or situation to the next and must take context into account in order to be effective. The process is thus necessarily incremental and relies on clearly defined objectives to succeed
in improving the efficiency of ICT use in education. This document presents major themes to assist educators in better integrating ICT with their teaching, and particularly allowing them to offer higher quality distance education programs to Mathematics, Biology, Chemistry and Physics students. An introduction to the theories and principals of ICT integration is presented within six themes, and further developed into seven specific learning objectives, which can be adapted according to the specific subject of the program.

### 6.1 Overview/Outline

The content of this module focuses on developing those teacher competencies and abilities common to all approaches to integrating ICT in learning, as teachers seek ways to improve their teaching. Examples of these general competencies include among others, ability to decide why, when, where, and how ICT tools will contribute to teaching objectives, how to choose from among a range of ICT tools those that are most appropriate to stimulate learning and improve the quality of education offered; ability to facilitate students’ use and analysis of information from the Internet and ICT-based sources in relation to learning in specific subject areas. Thus, the process of integrating ICT in subject specific areas is of necessity incremental and relies on clearly defined objectives for its effectiveness in education. The integrated use of ICT in subject curricula and classroom teaching and management, is a complex process, which is usually achieved by following a set of guiding parameters. In this module, there are two complementary activities: the first focuses on the theories and principles that underpin ICT integration in education; and the second is teachers’ computer-assisted practice in the use of ICT with support web-based portals. The module content provides a teacher training curriculum that incorporates the pedagogy, i.e. specific learning objectives and learning activities required to effectively integrate ICT into biology education. The principles are presented below, in the following form:

### SECTION I: Conceptual framework

1.1 Required course materials
1.2 Module Rationale
1.3 General objectives, specific objectives
1.4 Learning activities
   1.4.1 Pre-assessment
   1.4.2 Key concepts
   1.4.3 Required readings: references, summary and description
   1.4.4 Multimedia resources
   1.4.5 Useful links: address, title, screenshots, summary and description
SECTION II: ICT integration in specific disciplines

2.1 Crosscutting learning activities
   2.1.1 Report on required readings + evaluation
   2.1.2 Report on selected readings + evaluation

2.2 Biology specific learning activities
   2.2.1 Activity one + evaluation
   2.2.2 Activity two + evaluation
   2.2.3 Activity three + evaluation

2.3 Module synthesis
2.4 Final evaluation
2.5 References
6.2 Graphic organizer

Pedagogical integration of ICT in Biology

**Première partie**
- Aspects théoriques
  - Matériel didactique approprié à chaque discipline
  - Objectif général
    - Objectifs spécifiques
  - Activités d’apprentissage
    - Évaluation préliminaire
      - Concepts-clé
    - Lectures obligatoires
      - Ressources multimédias
      - Liens utiles

**Deuxième partie**
- Application disciplinaire des TIC
  - Activités transversales d’apprentissage
    - Complément des lectures obligatoires + Évaluation
    - Complément des lectures au choix + Évaluation
    - Activités spécifiques d’apprentissage
      - Activité #1 + Évaluation
      - Activité #2 + Évaluation
      - Activité #3 + Évaluation
      - Activité #4 + Évaluation

**Troisième partie**
- Synthèse générale du Module
- Évaluation formative
- Brève biographie d’auteurs du module
- Références
VII. General Objective(s)

The module’s general objective is to help student-teachers of Biology, to know how to use ICT as a tool for designing new learning environments for their own subject-specific purposes and to help their future students to use ICT. Exposure to this module is expected to provide the student-teacher with the knowledge, skills and attitudes to better use technology in their lesson-planning and lessons, research, communication, problem-solving, and continuing professional development.

VIII. Specific Learning Objectives (Instructional Objectives)

The principles of ICT integration in education are expressed here as seven specific learning objectives for Biology. Students should be able to:

1. Critically apply the pedagogical principles of ICT integration in education.
2. Develop and facilitate ICT-based learning activities in the context of teaching biology.
3. Analyse and evaluate appropriate content and context for the use of ICT in biology teaching.
4. Use appropriate and varied communication and multimedia tools (emails, Websites, etc) in teaching and learning biology.
5. Use ICT efficiently in research, problem solving and project-based learning in biology.
7. Integrate ICT appropriately into chemistry curriculum activities that will foster students ownership of their ICT-rich learning environment.
IX. Teaching And Learning Activities

Pre-assessment: are you ready for this module?

**Learners**

In this section, you will find self-evaluation questions that will help you test your preparedness and readiness to complete this module. You should assess your performance objectively after completion of the self-test, and carry out the recommended action based on your score. We encourage you to take your time in answering the questions.

**Instructors**

The Pre-assessment questions below are meant to guide the students to help them decide whether they have sufficient background knowledge and skills required for the completion of the content presented in this module. As the instructor you should encourage your learners to evaluate themselves by attempting all the questions provided below. It is strongly suggested that the individual student abides by the recommendations made on the basis of the mark obtained. Education research consistently shows that compliance with the recommendation will ultimately help learners to be better prepared for linking the new with their existing knowledge.

**9.1 Self-evaluation of ICT competencies**

Evaluate your ICT competencies for this subject specific ICT integration exercise. If your score is equal to or greater than 60 out of 75, you are ready to use this module. If your score is between 40 and 60 you may need to revise your previous ICT basic skills course. A score less than 40 out of 75 indicates you need to do a basic ICT skills course. Try the following questions and evaluate where you are in the ICT user spectrum.
# ICT Integration in Biology

## Areas of Competence

<table>
<thead>
<tr>
<th>A) General</th>
<th>Level of confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>1. Familiar with the AVU Basic ICT Skills (using word processors, spreadsheet software, web navigator, etc. See list of pre-requisites).</td>
<td>1</td>
</tr>
<tr>
<td>2. Confident in guiding AVU’s ODeL trainee (lesson Planning, reference links, etc.)</td>
<td>1</td>
</tr>
<tr>
<td>3. Using software (interactive whiteboard software to create and save flip charts). (Annotation desktop mode, flip chart, paste in objects, load images.)</td>
<td>1</td>
</tr>
</tbody>
</table>

## B) Using ICT in Numeracy

4. Whole class teaching & group work Software e.g. Geogebra, Graph, ActivPrimary, Easiteach Maths, RM Maths, ICT in Maths, websites. Using ICT in Literacy
   (Whole class teaching & group work)
5. Software e.g. ActivPrimary Creating resource in generic software (e.g. TWAW, Talking First Word, My World3), websites.

## C) Using ICT in Biology

6. Using virtual labs and simulations (e.g. Optics Bench Applet http://www.hazelwood.k12.mo.us/~grichert/optics/intro.html, Physics 2000)
7. Using Biology modelling software (e.g. Crocodile clips).
   See http://www.crocodile-clips.com/science/
8. Use of other ICT resources (e.g. Junior Insight & Sensing/sensor equipment, digital camera, E-microscopes). Active Primary for whole class teaching

## D) Using ICT in Science

9. Using generic software to present information and for creating pupil resources in (e.g. TWAW, Talking First Word, My World, data handling programs), Data logging Research using websites & CD ROMS,
### E) Using ICT in other curriculum areas

10. Active Primary, creating resources in generic software (e.g. TWAW, Talking First Word, My World), websites, Micropedia CD ROM, other specific CD ROMs, digital camera, digital video camera...

11. Using the shared areas on the AVU and/or PI site (Read, Write & Homework) to put templates and files for the pupils, to share work.

12. Using Office software (Word, Excel, PowerPoint) for professional use e.g. to create and adapt teaching resources, write reports, plan out timetables, record pupil data.

13. Use the Internet for professional development (teaching resources, teaching information, copying images)

14. Use software to record pupil’s progress

15. Use of other ICT resources (e.g. scanner, digital camera)

### 9.2. Precautions about misconceptions in teaching and learning

**Learners**

This section offers support to students who are apprehensive about working with computers or using the Internet. You will also find in the section a number of useful tips that would help you to avoid some of the more common pitfalls, misconceptions and prejudices. For you to appreciate the relevance and appropriate application of ICT, you need to take a critical look at the perceived and real risks if any, of teaching with ICT.

Misconceptions about ICT sometimes arise as a result of misunderstandings or insufficient knowledge one has about how things work. The preconceptions held might be close to the correct view but are essentially incorrect. For example, children may have a naïve view of how the computer works, crediting it with super intelligence beyond the capabilities of any existing machine. Such views may have been developed as a result of some of the more mind boggling things information technology has been able to achieve in modern times. Hence, young people’s alternative frameworks often involve perceptions and/or limited understanding of the nature of technology. But there is no doubt that access to ICT provides one of the best educational facilities necessary to prepare young people to play full roles in contemporary society and to contribute to a knowledge economy.

However, not all teachers are convinced that ICT should be an integral part of their teaching strategies (Galanouli, Murphy, & Gardner, 2004). Resisting change is a state of mind for many teachers, and it is one of the most difficult barriers to effective ICT integration. To address some of the misgivings people may
have, be prepared to discuss some of the concerns raised, if necessary engage in constructive debates that are meant to clarify issues and acknowledge limitations where they exist. Issues such as the role of ICT in a changing society could be framed for discussion in a way that provides for informed opinion. The assertion for example that: “The Internet is potentially dangerous and people just want to sell you anything imagineable without any moral compunction”; “Computers are ‘boys’ toys’ and not interesting or useful to girls” are certainly interesting statements that need to be justified or debunked. Similar topics can be proposed for elucidation, even your own perceptions and attitude towards the use of ICT in schools.

Some Misconceptions in ICT use

Here are some of the more common misconceptions:

- That a graphics file is different from a text file, or a word processor file.
- That a file currently being edited is merely a copy of the file in hard storage (and important too to note the exception for database files).
- That a data file for a picture is as different from a data file for text as a photograph is from a printed page. This is of course not true.
- That as one edits a document in a word processor the data file is automatically changed. But this is not true (until it is re-saved). The exception is a database in which any editing immediately changes the data file.
- That all web-pages are available indefinitely, without any time limit. This is not always the case. One needs to check the web site addresses before hand, to see whether they have limited life and when they are about to change.

Precautions

Students need guidance on the fine details of searching information from the Internet

As the instructor/teacher:

- Avoid vague statements such as “search the Internet for……” particular types of activities. Most pupils need more direction than that. If you want pupils to do an Internet search, give them a preparatory activity where they consider appropriate key words to enter into a chosen search engine. It helps for the teacher to do a pre-lesson check to ensure that the selected key words produce the desired results.
- Check the time it takes for the learning materials to be downloaded from your chosen sites before your lesson. If it takes an unusually long time then you have to plan your lesson accordingly.
- Check the language used in your chosen web sites, to see if it is an accord with the language of instruction.
• You may need to identify a short list of key words and concepts to be explained to pupils before they attempt any web site activities.

**Your first choice may not be available:**

• List some alternative web site addresses in case your first choices are unavailable.

**Undesirable links and updates:**

• Search your selected web sites for links to undesirable web sites and advertising material. New links appear all the time. Check these just before the lesson.
• Search your selected web sites for features, which invite responses by email. See if a school email address can be submitted or if the option can be disabled. Avoid using web sites, which invite personal response by e-mail.

**Key words: Their usefulness and limitations:**

• Check for American spellings especially of key scientific words, e.g. Sulfur, instead of sulphur.

**Access to/from the school computer may be restricted:**

• Some school computers are programmed to block the saving and downloading of files, so the saving of files is limited.
• Some school computers block certain web sites, denying access.
• Check the computers, which you will use, for any special features before the lesson.

**Backup an important aspect of ICT:**

• Try to give out web site addresses in an electronic format, either saved to favourites, as an e-mail, on a floppy disk or on a CD ROM. Avoid writing long addresses on a board for typing into computers by hand. Typing wrong web site addresses can be very demoralizing to pupils.
• Keep a spare copy of your list of web site addresses on your own personal flash disc, floppy disk or CD ROM and keep this with you during the lesson.
• Once you have made your list of safe web sites, make it available to the pupils electronically, through a departmental web site, an electronic conference like First Class, or e-mail.
Try to save your chosen sites to “Favourites” on the computers, which you will use. After you click the “Add Favourite” button, click to tick the box “Make available offline”. Not all sites can be saved in this way. Those that can will be saved onto the machines, which you are using. This gives you the option to use the web site during the lesson without an active Internet link. Alternatively, you could burn CD ROM copies of the web sites, which you wish to use during the lesson, using a CD rewriter, and load the web sites before the lesson starts. The only disadvantage is that the CD ROM copies of the web site are not updated when the web site is updated.

**Not all students have internet access at home:**

- You can tell pupils to use the Internet to support homework. However, you should provide computer access at school before the homework deadline for those who do not have access to a computer at home.
- If you present your small selection of web sites to the pupils as a CD ROM they do not have to go on-line and they can have a virtual Internet experience.

**Current and likely future developments in ICT.**

Predictions about future development trends for ICT generally involve adjectives such as ‘smaller, faster, and cheaper’. Increasing miniaturisation, portability and capacity of systems mean that the range of uses for ICT is increasing exponentially. The next major developments are likely to be:

- Wider adoption of technology such as USB, which will cut down the number of leads trailing from the back of computers as more devices will be ‘piggy-backed’ on to a single connection;
- ‘Bluetooth’ technologies, which make use of radio linking and will cut out the cables altogether. Faster access to the Internet with ‘broadband’ connections becoming widespread, which will lead to increased use of online multimedia resources such as audio and video. The implication for schools is that they must continue to play ‘catch up’, devoting significant resources to investment in technology and training.
X. Key Concepts (Glossary)

Learners

In this section, you will find key concepts useful in order to complete this module.

You shouldn’t consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

Instructors

The key concepts placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this instructional and learning sequence helps learners to be better prepared to link previous knowledge to the new one.

**ICT**: Information (I) and Communication (C) Technologies (T) - the term ICT encompasses innovative audiovisual, computing and telecommunications techniques which allow the acquisition, processing and storage of information. Many of these techniques come directly from computing and communications. A number of acronyms are used, including IT, NT and IS. The term ICT is becoming more and more common in science, in Open and Distance Learning, and in Pedagogical Integration of ICT.

**Pedagogical Integration of ICT**: This concept is not limited to the establishment of networks and/or the installation of equipment. It includes the use of technology in schools to improve learning and to facilitate educational development. Among other definitions, this concept implies a process of appropriate, regular, and regulated use of interactive technology with incurred beneficial changes in school practices and student learning.

**Software**: These are programs initially conceived to facilitate consumer use of ICT. There are various types of programs used in the Pedagogical Integration of ICT including learning, open source and “free” software. A number of support mechanisms exist to assist teachers and students in becoming comfortable and efficient with ICT. This support is often presented in the form of CD-ROMs, tutorials, exercises or other didactic material.

**Web Sites**: These are a collection of files (HTML pages, images, PDF, audio, video, Flash-animations) and folders forming the structure of a site, placed together in computer memory (on a work station during the development phase and a server when published), and linked together using hypertext. Access to a website can be global, using the World Wide Web, or limited to a local network. For any site to be accessible externally, web-server software must be operating on the server where the site is stored.
**E-Learning**: is a term used to refer to learning which takes place online. Self-directed learning plays an important role in this type of education, demanding an increased level of learner autonomy. E-learning programs can be completed remotely using the Internet, or can include short sessions of face-to-face teaching.

**Synchronised communication**: Refers to a mode of real-time communication, using tools such as Instant Messaging, chat rooms, discussion forums, conferencing systems and bulletin boards.

**Non-synchronised communication**: E-learning offers the option to desynchronise educator and learner time, allowing them to communicate based on their own schedules, in a non-synchronised manner, through multimedia information exchange networks – for example using email or e-platforms to submit work.

**E-portfolio**: Also called a digital portfolio, this tool is unique in that it can manage about a dozen file types (text, images, audio, video, presentations, and hyperlinks). This new technology allows learners to subscribe to a portfolio, to organise their work, to be advised of updates, and to take tests and quizzes, in real-time. It is possible to communicate with the owner of a portfolio on edu-portfolio.org, either by email, or via the “comments” function. Overall this tool is flexible, simple and easy to use, allowing information and evaluations to be organised and exchanged. Its potential applications offer very attractive prospects to E-learning programs.

**Internet**: Connection to a very large number of computers using communication networks, such as telephone lines, to exchange information worldwide. The Internet is, however, distinct from the World Wide Web (www), which, like email, is only one of the principle services available through the Internet.

**Intranet**: This concept generally designates regulated connection between a group of authorised users. A password can be required for members to access and exchange information on these smaller networks (which use similar technology to the internet). Web sites, or web pages, are examples of networks that use Intranet. In E-learning Intranet networks are an efficient way of exchanging information between learners, educators, and peers.

**Collaborative work**: It is an activity in which learners perform all work using the tools of distance communication.

**Puberty**: is the stage of development in a man which translates the passage from childhood to adolescence, in other words of infertility to fertility. It is during this stage that there is development of secondary sexual characteristics in boys (hair, deeper voice, ejaculation ...) and in women (the appearance of breasts, menstruation, development of the hips ...).

**Sexual cycles**: it is a cyclical period of time that takes place entirely on physiological and anatomical changes in an individual. Cases of menstrual cycles in women are an example.
**Hormone:** Chemical substance produced by endocrine cells and acts through the bloodstream to regulate the action of specific organs.

**Educational outing:** This is an educational activity that takes place outside the classroom and is designed to examine natural phenomena in situ.

**Problem Solving:** is an educational-based approach implementing evidence to solve a given problem and involves an individual or team-oriented effort.

**Simulation:** The animated simulation of a natural phenomenon is a reproductive strategy of a complex phenomenon for scientific, recreational or training purposes.

**Animation:** setting a process in motion by assembling film still images constituting the course of action.

**Chat:** a form of synchronous communication in writing using a computer and allowing participants to discuss a given topic.

**Forum:** is a form of asynchronous communication in writing using the resources of a computer where each participant makes a contribution that will be read later by other members.

**Food chain:** The food chain can be understood as a set of living creatures linked together in a process of production and consumption of energy and matter in a given ecosystem.

**Food Web:** a nested set of food chains that connect the bodies of an ecosystem.

**Ecosystem:** This is the structural and functional unit of the biosphere, and is a group of biological communities coexisting in the same physical environment.

**Modeling:** makes any phenomenon graphically and visually comprehensible.

To enrich your vocabulary on Open Distance Education, please click on these few helpful links:

http://www2.educnet.education.fr/sections/superieur/glossaire/

http://www.ymca-cepiere.org/guide/glossaire.htm

http://www.anemalab.org/eformateurs/glossaire.htm
XI. Compulsory Readings

Learners

In this section, you will find compulsory readings useful in order to complete this module. You shouldn’t consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

Instructors

The compulsory readings placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

Compulsory reading #1

Complete reference


Abstract: This book has two objectives: the first to delineate an ICT educational program for secondary school teaching that responds to current international trends. The second objective is to outline a professional development program and to support teachers in its implementation. In addition, it lends a practical and realistic approach to educational programs and teacher training, which allows efficient implementation with a given set of resources.

Rationale: This book is a UNESCO offering which aims to support educators and students in better integrating ICT, including multimedia, e learning and distance education, in the processes of training and knowledge sharing in the field of education. A particularly well-organized document, it offers examples of ICT applications in Mathematics, Biology, Physics and Chemistry teaching.
Compulsory Reading #2

Complete reference


**Abstract:** This document is a scientific journal that surveys the impact of ICT in education. In particular, it notes the recent progress in classroom instruction. This journal also explores the inherent and current challenges of fully integrating ICT in education in a dynamic policy environment. In short, while demonstrating an increase in comfort with ICT amongst users, and that their use has increased significantly in the last two years, this document reveals that there is also real evidence of the positive impacts of ICT use in education.

**Rationale:** This document is a valuable resource which allows a better comprehension of the importance of ICT as a set of educational support tools, especially in Open and distance learning. The evidence clearly presented in this text suggests directions for the development of new content for e-learning programs.

Compulsory Reading #3

Complete reference


**Abstract:** This document is a collection of references for teaching with ICT. It presents a variety of methods to integrate ICT in teaching. The document, compiled by specialists, synthesizes a number of examples, and presents lessons learned on ICT use in schools in a variety of countries. These lessons could help improve the planning and integration of ICT in education. The text suggests tools to guide both policymakers and users in their advocacy, as well as to support ICT initiatives in education.

**Rationale:** This document is a reference for ICT use in teaching and learning in specific discipline such as Biology, Chemistry and Physics. Like other texts in the series it helps to better understand the process of integrating ICT in teaching the disciplines and in the use of technology to enhance learning.
Compulsory Reading # 4

Complete reference


**Abstract:** This text is the next in a series of research reports produced by the UK organisation BECTA, on the educational impact of ICT. It addresses issues related to the use of ICT in disciplines such as math and science. It presents, in four stages, the relative gains of regular and occasional users of ICT in each discipline.

**Rationale:** It is important to read this document to better appreciate the benchmarks, and the real and potential impacts, for and of ICT use on learning in scientific disciplines. African teachers and learners faced with substantial challenges in their education systems can benefit from the experiences presented in this study to integrate ICT in their training practices.

Compulsory Reading # 5

Complete reference


**Abstract:** This document addresses decision-makers, teachers and students who are faced with the daily challenge of broadening educational programs through Open and Distance learning. Among other objectives, this document attempts to bring to light responses to fundamental questions in open and distance learning for teachers – What does this training consist of, what is the curriculum and who are the educators, is this training appropriate, who are the users, how should it be planned and organised, what technologies can be applied, how can it be financed, how can teachers develop competencies, how can they access these? These are the major questions broached in this important reference document for open and distance learning.

**Rationale:** This document addresses the inherent challenges of teaching in Open and distance learning. As a resource the text provides suggestions for financing, planning organising and activities, educational practices and evaluation. The document therefore presents useful information for collaborative work and further success in the field of Open and distance learning.
Compulsory Reading # 6

Complete reference


Abstract: This text presents the fundamental ideas, which mark the way for ICT integration in education. The theories herein centre around six poles, which together provide the elements essential for consideration in the process of bringing ICT to learning the sciences.

Rationale: A clear objective is only as useful as a clear path towards it - this principal certainly finds application in education – for, while targets may be well defined, the path towards them must also be marked. It thus seems appropriate to gain familiarity with the issues facilitating the integration and application ICT, so as to prepare and pilot learning activities and to manage teaching.

Required reading # 7

Complete reference: Group work:

What is collaborative learning? By Barbara Leigh Smith and Jean T. MacGregor

Abstract

This document deals with collaborative learning provides information on the rationale that educational practice. The collaboration promotes the creation of collective knowledge but also socializes the learner. It therefore relies on socio-constructivism. It applies to different learning situations. The approaches are as diverse as the goals and processes.

Rationale

This document is recommended, as there are several situations that may be helpful, particularly in understanding the concepts, applications, and strategies.
Required reading # 8

**Complete reference**: Pierre STOUFF. *Je peux transmettre la vie*...http://pst.chez-alice.fr/svtiufm/vie.htm

**Abstract**: This course on reproduction is divided into 5 chapters: Reproduction in both sexes; Fertilization and labor cooperation; Inheritance; Medical and non-medical applications; ethics of reproduction. The approach is novel and differs from the textbook.

**Rationale**: This text is offered for the original approach it takes, and you will be aware of different ways of approaching the theme of reproduction. The very expressive illustrations will be useful for design work with your students.

Required reading # 9


**Abstract**: This document is remarkable. The style is very simple. Images that are available very colorful and pleasant. Animations and simulations (folliculogenesis, hormone levels, ...) are proposed. It is a very educational paper that offers exercises at the end of text.

**Rationale**: This document will certainly be very useful in that the approach is easily replicable in the classroom. You can break down the elements of simulation into images that can be analyzed by the students.

Required reading # 10


**Abstract**: This document provides information on varied national parks and reserves of Senegal, particularly the Niokolo Koba National Park (the largest), the park of the Lower Casamance, the Biosphere Reserve of the Saloum delta, and the Bird Sanctuary. It is lavishly illustrated.

**Rationale**: This document is offered because it might help in reflecting but also guide them in finding information about your country. However, it will broaden the search for regulatory and legal aspects (text specific to your country, international agreements).
Required reading # 11


**Abstract**: The author identifies the possible fields of application of the simulation (human biology, ecology, immunology). However, it must be said that most of the text focuses on immunology.

**Rationale**: This document is offered, because you will be able to deal with simulations in biology, but also take into account certain elements (time, environment) that may fall within the categories of assessment criteria.

Required reading # 12


**Abstract**: This paper shows that simulation is irreplaceable in some cases such as photosynthesis. It presents the advantages of simulation, including the tremendous time saved, free testing, and the confrontation of students with regards to experimental situations.

**Rationale**: This document, although brief, is a significant contribution to those who questioned the teaching aids conferred by ICT.

Required reading # 13


**Abstract**: This paper presents the model of the pelagic production. It deals with biogeochemical cycles, particularly nitrogen. In other words, it is to understand how is the transfer of autotrophic nutrition (Diatoms, Dinoflagellates ..) to autotrophs (Mesozooplankton, Microzooplankton).

**Rationale**: This text offers a model of trophic relationships that can be analyzed as part of a class. This model can help develop skills in modeling.
XII. Multimedia Resources

Learners

In this section, you will find multimedia resources useful in order to complete this module. You shouldn’t consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

Instructors

The multimedia resources placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

Important resources for learning biology

Resource 1: Animated videos of male and female genitalia

Abstract: These videos show the structure and operation of the genitals of men and women. For example, for the woman, the external and internal organs are shown, but also the development of the follicle, ovulation, and a part of fetal life.

Rationale: These videos will be very useful because they present very interesting teaching materials to illustrate a course on reproduction.

Resource 2: Compilation CD of biological images

Abstract: This CD Rom is a bank of images on different levels of biology: molecular, cellular, tissue, organ, organism.

Rationale: The CD ROM is a learning resource. You can use it to illustrate your lessons or to develop content for a formative or a summative evaluation
Resource 3 : The discovery of landscapes across the Internet

SHEET ROUTE: 6th level
claudia@parisbalades.com http://www.tice-hg.net/utiliser/paysages_6e.htm

Abstract: This site describes a teaching experiment conducted with students on the discovery of the Internet landscape. With the proposed approach, the work instructions are explicit. It provides resources to support sites for teaching about the landscape.

Rationale: In this site you will find a reproducible educational approach that can inspire the use of ICT in almost all areas of teaching and learning. Use it wisely and you will improve in performance.

Resource 4 : The Clionautes

Eric Mauriange (2003) : PAYSAGES ET TICE. Des ressources pour enseigner...
http://www.clionautes.org/spip.php?article214

Resource 5 : Center for Mediated Teaching in Biology

List of software used in teaching SVT in college or high school. This list downloaded at the URL below is one of the documents annexed to this module.
http://www.u-psud.fr/sitesiecle.nsf/logi_col_lyc!OpenPage

Resource 6 : Inspiration Software

http://inspiration.demarque.com

Abstract: Inspiration is a software that helps design conceptual maps, organizational charts, diagrams, graphs, and plans. He can prepare a presentation;

Rationale: It facilitates the preparation of a presentation and therefore helps to teach better and to learn better. You can download it and there are also tutorials.

Resource 7 : ThinkGraph Software http://www.thinkgraph.com/

Abstract: ThinkGraph is also a 2D drawing software. It can make conceptual maps using a methodical organization of ideas.

Rationale: We recommend you to use this tool, because it will be of great use in your lessons. Your students can also easily master it.
XIII. Useful Links

Learners

In this section, you will find links you will find useful in order to complete this module. You shouldn’t consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

Instructors

The links placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.
Useful links # 1

Big Brown Envelope Educational ICT Resources

http://www.bigbrownenvelope.co.uk/

Description

This site Web provides access to the very educational resources for teachers to aid use of ICT in their lessons.

Rationale

The success of the pedagogical integration of ICT in teaching and learning largely depends on the availability of resources to bring to life important aspects of the training content. This site hosts a number of resources, which could help educators fill-out, enrich their lessons, and make them more exciting.

Useful links # 2

Educ - Portfolio

www.eduportfolio.org

Description

Edu-portfolio is a website which presents, in a clear and straightforward manner, a virtual portfolio – a very important training tool in distance learning.

Rationale

A secure method for organising work is primary to success in an open and distance learning program. A portal through which to archive content, in addition to a discussion platform, makes for a dynamic educational environment.
Useful links # 3

ICT resources and guidance for teachers at all Key Stages
http://www.teachernet.gov.uk/teachingandlearning/subjects/ict/

Description
Practical help on using ICT in teaching is provided by TeacherNet.

Rationale
The application of technology in distance learning presupposes the availability of well-developed and reviewed content. Teachernet, to this end, assists educators in the complex and fascinating challenges of integrating technology with their teaching methods, by providing tools and pedagogical content.
Useful Links # 4

**UneSco Bangkok: ICT Resources for Teachers CD-ROM**

http://www.unescobkk.org/index.php?id=3871

**Description**

*ICT Resources For Teachers CD-ROM* contains a set of ICT-based resources for teaching and learning of science, mathematics, etc. for secondary-level students, including simulations, video clips, interactive learning objects for quizzes, animation, and other kinds of multimedia learning activities. The materials and lesson plans provided here are organized and relevant to subjects. A separate directory is provided to give an overall view of the types of resources available.

**Rationale**

In pedagogy the use of a variety of available resources stimulates learning. Appropriate audio-video support for learning activities which include diverse, information-rich, content, seems to hold learner’s attention throughout the training process. Additionally, learning activities appear less monotone. This UNESCO website is worth a visit because it provides a collection of these resources for learning math and the sciences.
Useful links # 5

4Teachers: Home Page
http://www.4teachers.org/

Description

4Teachers.org works to help you integrate technology into your classroom by offering FREE online tools and resources. This site helps teachers locate and create ready-to-use Web lessons, quizzes, rubrics and classroom calendars. There are also tools for student use. Discover valuable professional development resources addressing issues such as equity, technology planning and at-risk or special-needs students. Here you will find some of our resources to help you integrate technology into your curriculum, along with links to stories written by teachers who personally conquered integration challenges.

Rationale

Online learning is facilitated when available resources include a variety of multimedia resources and examples. As well, when these resources reflect real experiences of technology integration, they allow educators to discover new ideas and enhance their professional development.
Useful link # 6

Education World: The Educators Best Friend
http://www.education-world.com/

Description
The Website provides free featuring collaborative projects, virtual field trips, educational games, and other interactive activities.

Rationale
Problem-based and collaborative learning are standard pedagogical approaches in Open and distance learning. It is thus appropriate that learners and educators in the field visit this site, where projects and interesting interactive activities are available.
Useful links # 7

Resources to help students practice skills needed on state assessments

http://www.internet4classrooms.com/

Description

This Website provides resources to help students practice skills required on various assessments. Online Modules are available for elementary, Middle and high school students’ assistance.

Rationale

The Internet holds an increasingly important place in schools. Because they are considered role models teachers must not fall behind their student’s ability to use email and navigators. ICT use generally, and the Internet in particular, requires at least basic competencies. Internet4Classrooms provides a portal that reviews material to assist educators in effectively using the Internet.
Useful links # 8

http://www.unescobkk.org/index.php?id=1366

This website includes a number of free, downloadable resources and provides substantial support for childhood education. Also available is free software for educators.

Rationale

Games play an important role in children’s lives. They contribute, in large part, to motor and cognitive functions as well as accelerating the process of gaining social skills and knowledge. This UNESCO website is an easy-access source for a variety of interactive learning activities which supports different aspects of childhood development.
Useful links # 9

Unesco-Bangkok: ICT in Education

http://www.unescobkk.org/index.php?id=1366

Description

Five principal themes related to ICT integration policy are available on this UNESCO website. Teacher training, teaching, learning and monitoring are explored.

Rationale

Teacher training is only one, but perhaps the foremost, among the multiple preconditions necessary for the successful integration of ICT in education. In addition to reviewing information related to learning and teaching, this website also provides useful information on ICT integration policy.
XIV. Learning Activities

Learning activity # 1

Title of Learning Activity: Written report on compulsory reading

To note: Reading is an especially important activity in Open and distance learning. To best grasp the concepts of the pedagogical integration of ICT, the readings for each activity are compulsory. Two texts accompany activities #1.1 and #1.4, and a single text for #1.2 and #1.3

Learning activity # 1.1

Title of the learning activity: Summary of critical Reading

Summary of learning activity


Reference for the compulsory reading:

- UNESCO (2004). Technologies de l’information et de la communication en Éducation : Un programme d’enseignement et un cadre pour la formation continue des enseignants.Division de l’enseignement supérieur. ED/HED/TED/1
Detailed description of the activity: suggestions for completing the assignment

Read the UNESCO (2004) text and produce:

- A 3-page (maximum 1300 words, 1.5 line spacing) summary report. The report should clearly bring out the major points of a professional development plan that would allow teachers to succeed in integrating ICT in their discipline.
- A synthesis table presenting the basic skills necessary to apply ICT in pedagogical practices.
- An analysis of the important themes developed in the two texts, noting opportunities to integrate them in your discipline or teaching practices.

Formative evaluation

The evaluation of the learning activities is based on the quality of the learner’s analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Summary report (40%)
- Synthesis table of basic ICT skills (30%)
- Analysis and opportunities for integration (30%)

Learning activity #1.2

Title of the learning activity: Creation of a trainer profile in distance learning.


Summary of the learning activity

Fundamentals concerning the use of ICT by teachers in the context of Open and distance learning.
Detailed description of the activity: suggestions for completing the assignment

Having read the UNESCO (2004) text (ref. lesson activity 1.1):

- Write a brief critique (600 words, or two pages at 1.5 line spacing) responding to the major challenges faced by teachers in Open and distance learning, as presented in the text.
- Illustrate, in a table, the competencies required of, and the ideal profile for, an Open and distance learning educator.

Formative evaluation

The evaluation of this activity will focus on both content and presentation. 60% will be dedicated to the quality of the analysis, and 40% to its presentation, particularly the competency table.

Learning activity # 1.3

Title of the learning activity: Reading critique.


Summary of the learning activity

The theories and guiding principles of the pedagogical integration of ICT in education.

Detailed description of learning activity: suggestions for completing the assignment

Read thoroughly the text on the fundamentals of ICT integration in education, and write a report that briefly (in two pages, 1.5 line spacing) presents the important aspects of ICT integration, as outlined in the document.

In an additional section, critique the text, and relate its themes to professional development for educators.
Formative evaluation

The evaluation of the learning activities is based on the quality of the learner’s analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Report on the reading (50%)
- Critical analysis and link to professional development (50%)

Learning Activity # 1.4

Title of the learning activity: ICT impact “success stories”.

Reference for the readings


Summary of the learning activity

Various positive impacts of ICT use in mathematiques and science.

Detailed description of the activity: suggestions for completing the assignment

Begin by reading the two Becta (2005, 2002) texts on the evidence of positive impacts of ICT on learning, then:

- Write a one-page synthesis report and create a PowerPoint presentation on the positive impacts of ICT on the process of learning.
- Present two success-stories related to teaching using ICT (or two personal accounts of the same). Note links to the advantages outlined in the text. The accounts must highlight the important lessons to be learned (while noting significant risks and challenges).
Formative evaluation

The evaluation of the learning activities is based on the quality of the learner’s analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Production of the synthesis report and PowerPoint presentation (50%)
- Presentation of success-stories/accounts (50%)
Learning activity # 2

Title of the learning activity: Report on reading of your choice

Detailed description of the activity: suggestions for completing the assignment

Choose two readings available on the Internet, draw from them two opposing or contradictory scientific opinions. Now report (in 600 words, about two pages) information from various sources – what does this demonstrate? For example, both Darwin’s theory of evolution and Creationism are found on Wikipedia (www.wikipedia.org). Your report should conclude by drawing out the challenges you may face in this context, as a teacher working with students.

Formative evaluation

- The authenticity of the readings (20%)
- The brief resume of the two texts (40%)
- The critical analysis of the readings (20%)
- Presentation of the material, within the defined parameters of the assignment (20%)
Learning activity # 3

Title of the learning activity : Teaching and learning biology with and by ICT

Introduction

The information technology and communication (ICT) is developed in the educational field. Teachers of biology use it to present or introduce an activity or an illustration, or explaining a fact or a process. This activity will help the beneficiaries of training to realize the large potential of information technology and communication (ICT) to improve educational practice in the field of biology in particular, and life and earth sciences in general. In other words, with the course on human reproduction that will support this learning activit, there will be comprehensive ICT applications in:

• research tasks and organizing information
• educational tasks (PowerPoint presentation, use of an exercise for self-assessments and appraisals, communication and collaboration, modeling);
• administrative tasks (manage the course and grades of students by using an Excel spreadsheet, for example);
• social tasks (opening the school to social pooling). These tasks will be the pretext to identify the uses of ICT in teaching and learning of biology.

Specific activity objectives

Specific knowledge objectives

After the activity, you will be able to:

• define the fundamental concepts of integration, collaboration;
• define the concepts of puberty, viviparity, internal fertilization, physiological regulation, cycles, hormone;
• quote various possibilities for integration and use of ICT in teaching and learning in biology and more specifically on human reproduction.

Specific method objectives

At the end of learning, the beneficiaries of the training will:

• identify key areas of application of ICT based activities carried out on human reproduction, in particular, and life sciences and earth sciences in general;
• achieve, through collaborative work using a computer, a conceptual map on the main areas of application of ICT in teaching human reproduction, in particular, and life sciences and earth sciences in general;
• know when and how to use ICT in learning activities in reproductive biology, in particular, and life sciences and earth sciences in general;
• produce a reflective report on their activities.

Abstract of the activity

In this activity, which is somewhat of an introduction to the three other activities of the module, it will be a question of doing an overview of the integration of ICT into teaching and learning of human reproduction. You will, among other tasks, be identifying instructional, administrative, academic and social activities in which the teacher of biology will integrate ICT.

Individual work will be alternated with collaborative work. For this, you have to communicate via Internet chat or forum on the platform and together, design a conceptual map on the use of ICT in biology. You will produce a reflective report.

Key concepts

Collaborative work: It is an activity in which learners perform all work using the tools of distance communication.

Puberty: is the stage of development in a man which translates the passage from childhood to adolescence, in other words of infertility to fertility. It is during this stage that there is development of secondary sexual characteristics in boys (hair, deeper voice, ejaculation ...) and in women (the appearance of breasts, menstruation, development of the hips ...).

Sexual cycles: it is a cyclical period of time that takes place entirely on physiological and anatomical changes in an individual. Cases of menstrual cycles in women are an example.

Hormone: Chemical substance produced by endocrine cells and acts through the bloodstream to regulate the action of specific organs.

Key terms

1. Groupwork
2. Integration
3. Puberty
4. Cycle
5. Hormone
6. Viviparity
7. Internal fertilization
8. Physiological regulation
9. Genital device
10. Reproduction
List of important lectures

Text 1: Je peux transmettre la vie…

Pierre STOUFF

http://pst.chez-alice.fr/svtufm/vie.htm

Abstract

This course on reproduction is divided into 5 chapters: Reproduction in both sexes; Fertilization and cooperation; Inheritance; Medical and non-medical applications; Ethics of reproduction. The approach is novel and differs from the textbook.

Rationale

This text is offered for the original approach you will be aware of different aspects of the theme of reproduction. The very expressive illustrations will be useful for design work with your students.

Text 2: Je peux transmettre la vie …

Groupwork:

What is Collaborative learning? by Barbara Leigh Smith and Jean T. MacGregor

Abstract

This document deals with collaborative learning and provides information on the merits of this educational practice. The collaboration promotes the creation of collective knowledge, but also socializes the learner. It therefore relies on socioconstructivism. It applies to different learning situations. The approaches are as diverse as the goals and processes.

Rationale

This document is recommended because it presents several situations that may be helpful, particularly in understanding the concepts, applications and strategies.
**Texte 3 : The function of reproduction**

http://www.svt.edunet.tn/Zaghouan/svtza01/accueil.htm

**Abstract:**

This document is remarkable. The style is very simple. Images that are available very colorful and pleasant. Animations and simulations (folliculogenesis, hormone levels, ...) are proposed. It is a very educational paper that offers exercises at the end of text.

**Rationale:**

This document will certainly be very useful in that the approach is easily replicable in the classroom. You can break down the elements of simulation into images that can be analyzed by the students.
List of important resources

Resource 1: Animated videos of male and female genitalia

Abstract: These videos show the structure and operation of the genitals of men and women. For example, for the woman, the external and internal organs are shown, but also the development of the follicle, ovulation, and a part of fetal life.

Rationale: These videos will be very useful because they present very interesting teaching materials to illustrate a course on reproduction.

Resource 2: Compilation CD of biological images

Abstract: This CD Rom is a bank of images on different levels of biology: molecular, cellular, tissue, organ, organism.

Rationale: The CD ROM is a learning resource. You can use it to illustrate your lessons or to develop content for a formative or a summative evaluation.
List of important links

Link 1: Fertility.com

http://www.fertility.com/francais/concern/index.jsp

Abstract

This site offers questions and answers on practical aspects of life: Assessing fertility; understanding fertility; optimizing your fertility, infertility in women and in men ...

The issue of pregnancy (process, hormones) is also discussed. Real-life examples are reported.

Rationale

This site will help you meet and find answers to practical situations. It complements the academic dimension addressed in the readings. The style is very simple, which adds clarity to the words.
**Link 2 : 9 months and more**

http://www.neufmoisetplus.com/mater/40semaines/foetus/index-foetus.htm

Abstract

This site deals with embryonic and fetal development. The agenda begins during the first week of pregnancy. Other topics are also taken into account such as fertility, conception and motherhood. It offers strategies to monitor your condition and that of the child.

**Rationale**

We recommend you visit this site that will inform you on many aspects of reproductive health and give you practical advice.

**Link 3 : Normal chronological development of the embryo**

http://www.boskitos.com/fac/embryologie/dvpt_embryon.htm

Abstract

In this site you will find details of embryonic development, including tissues and organs that develop with age. Very useful for those wishing to learn more on embryogenesis.
Rationale

Take time to visit this site. It will complement your information. The items you find there will certainly fuel an evaluation questionnaire.

Detailed activity description

The completion of this activity requires several tasks, including linking the activities of teaching and learning with opportunities to use ICT. Working groups will be organized. Working sessions will alternate with individual sessions of collaborative activities. Eventually, a collective production of a conceptual map will be available for members of each group.

Learning activities

Task 1: Census from the texts of proposed actions undertaken in biology education: Example:
- Microscope observation of sex cells (sperm and oocytes), early stages of embryonic life.

- Diagram of the reproductive tract of man or woman or as part of the ovary. Ability to edit an image in Paint
- Plotting curves on the changing hormone levels during the ovarian or uterine cycle in women. Simulations can be obtained with the computer
- Formulation of exercises
- Recording student’s grades
- Laboratory experiments, diagram, assessment, student’s grades, etc. ... 

Task 2: Teaching of biology where you use the computer as a tool: Example: PowerPoint presentation, reasearching information.
Task 3: Development of a table summarizing the correspondence between activities and the possible uses of computers.

<table>
<thead>
<tr>
<th>Activities</th>
<th>Outil informatique utilisé</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schematization</td>
<td>Paint</td>
<td></td>
</tr>
<tr>
<td>Animation of annotations</td>
<td>PowerPoint</td>
<td></td>
</tr>
<tr>
<td>Drawing graphics</td>
<td>ThinkGraph</td>
<td>Other software: Inspiration</td>
</tr>
<tr>
<td></td>
<td>mindmapper.</td>
<td>Other means of research</td>
</tr>
<tr>
<td>Researching information</td>
<td>Google</td>
<td></td>
</tr>
</tbody>
</table>

Task 4: Sharing of individual productions and discussion in a chat, forum or e-mail.

Task 5: Reflective report on the activity

Each group member develops a reflective report on the following points:

- What have I learned? Of the conceptual and technical, of organizing individual and group work, of collaboration.
- How did I learn?
- What helped me in my learning?
- How much time did I spend on this activity?
- Am I satisfied with my participation in this collective production?

What will my new skills change in my own professional activities, including my choice, use and integration of computer tools?

- What are the difficulties that I have encountered?
- How can I do to pass on these skills to my students?
Formative evaluation

True/false questions (0.5 points per question)
Check the correct answer.

1. Ovaries (female gonads) are developing the human fetus between the 4th and 7th week of fetal life
   □ True       □ False

2. Primary follicles appear at puberty.
   □ True       □ False

3. In postmenopausal women the ovary has feedback on the pituitary.
   □ True       □ False

4. The first ovarian follicles appear only in the 16th week of gestation.
   □ True       □ False

5. Ovulation releases a primary oocyte
   □ True       □ False

Multiple choice questions (1.25 points per question)
Check the correct answer.

6. The organ of gestation is
   □ The vagina
   □ The uterus
   □ The Fallopian tube

7. Ovulation lasts
   □ seconds
   □ minutes
   □ hours
   □ days
8. The testicles begin producing testosterone as of: (0.75 point)
   - the fourth week
   - the sixth week
   - the eighth week
   - the tenth week

9. The ovulation rate is:
   - the number of oocytes released at the same time
   - the number of oocytes possessed by the female
   - the number of oocytes expelled by a woman in her lifetime

10. A woman has, over the course of her life:
    - 600 ovulations
    - 300 ovulations
    - 200 ovulations
    - 100 ovulations

11. Which of the is false?
    - Karyogamy restores the diploid,
    - Karyogamy triggers the destruction of the envelope of the spermatozoid
    - Karyogamy awakens the female gamete
    - Karyogamy ensures the determination of chromosomal sex.

**Matching questions** (1.5 points)

12. Associate the following cells to their secretions.

<table>
<thead>
<tr>
<th>Cell</th>
<th>Secretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sertoli cells</td>
<td>Progesterone</td>
</tr>
<tr>
<td>Leydig cells</td>
<td>MPF (meiotic preventing factor)</td>
</tr>
<tr>
<td>Luteal cells</td>
<td>Inhibin</td>
</tr>
<tr>
<td></td>
<td>Testosterone</td>
</tr>
</tbody>
</table>
13. Vocabulary  (0.5 point per word found)
What is another name for :
   Rules
   Endometrium
   Mucus
   Spermiduct
   Rut
   Karyogamy
   Follicular degeneration

14. What are the four stages of spermatogenesis? (2 points)

15. Label the following schematic (3 points)

Modified from [http://www.svt.edunet.tn/Zaghouan/svtza01/accueil.htm](http://www.svt.edunet.tn/Zaghouan/svtza01/accueil.htm)
Correct answers

1. True
2. True
3. True
4. True
5. False
6. The organ of gestation is the uterus
7. Ovulation is a phenomenon that lasts several minutes
8. The testes begin producing testosterone from the eighth week
9. The ovulation rate is the number of oocytes released at the same time
10. A woman, during her sexual life, has about 300 ovulations
11. The karyogamy triggers the destruction of the envelope of the spermatozoid
12. Cell/secretion associations
   Sertoli cells secrete MPF (Meiotic Preventing Factor and inhibin)
   Leydig cells secrete testosterone
   Luteal cells secrete progesterone

13. Vocabulary.
   Rules = menstruation
   Endometrium = uterine mucus
   Mucus = glair
   Spermiducte = vas deferens
   Rut = estrus
   Karyogamy = amphimixia
   Follicular degeneration = follicular atresia

14. The four stages of spermatogenesis are: Phase propagation; growth phase, maturation phase, differentiation phase (spermiogenesis)
15. Labeling:
Learning activity 4 : Educational outing

Title of the activity : Collective achievement of a database on wildlife reserves and gazetted forests of my country.

Specific learning activity objectives

Specific knowledge objectives.
After the learning activity, the student should be able to :

• define the terms of integration, collaboration, problem solving;
• list collaboration tools available to students.

Specific method objectives.
After training, learning will be able to

- Seek additional information;
- Guide students in finding information on the Internet;
- Assist students to properly use e-mail accounts open for them;
- Direct a chat or a forum

Abstract of the learning activity

The outing is an educational activity that requires preparation, execution and operation. Each of these steps can be a reason to organize collaborative work using ICT and contributing to solving a problem. The outing will thus be a pretext to encourage the biology teacher to integrate ICT in their lessons and to organize activities for problem solving and collaborative work by students.

This activity will enable teachers to improve their teaching practices during outings, and for students to gradually build their knowledge using ICT.

Key concepts

Educational outing: This is an educational activity that takes place outside the classroom and is designed to examine natural phenomena in situ.

Problem Solving: is an educational-based approach implementing evidence to solve a given problem and involves an individual or team-oriented effort

Integration: This is the process by which the teacher brings ICT into their teaching practice.
**Collaborative work**: It is an activity in which learners perform all work using the tools of distance communication.

**Key terms**

1. Educational outing
2. Integration
3. Collaborative work
4. Problem solving
5. Communication
6. Herbarium
7. Collection

**Important readings**

**Reading 1**


**Abstract**

The welfare of animals is historically noted with reference to culture, religion, and under legal and philosophical context. The nutritional aspect is addressed along with the five basic needs of animals: freedom from pain, injury or illness; climatic stress or physical hunger, thirst, malnutrition, fear, and the possibility to express normal behavior.

**Rationale**

This text is important in that it raises awareness about animal welfare. It will allow learners to become more aware of animals. The general idea will be introduced in the report, including the legal and moral aspects.

**Reading 2**


**Abstract**

This document provides information on varied national parks and reserves of Senegal, particularly the Niokolo Koba National Park (the largest), the park of the Lower Casamance, the Biosphere Reserve of the Saloum delta, and the Bird Sanctuary. It is lavishly illustrated.
Rationale:
This document is offered because it might help in reflecting but also guide them in finding information about your country. However, it will broaden the search for regulatory and legal aspects (text specific to your country, international agreements).

List of important resources

Resource 1
SHEET ROUTE  6th level
The discovery of landscapes across the internet
claudia@parisbalades.com  http://www.tice-hg.net/utiliser/paysages_6e.htm

Abstract :
This site describes a teaching experiment conducted with students on the discovery of the Internet landscape. With the proposed approach, the work instructions are explicit. It provides resources to support sites for teaching about the landscape.

Rationale:
In this site you will find a reproducible educational approach that can inspire the use of ICT in almost all areas of teaching and learning. Use it wisely and you will improve in performance.

Resource 2
Complete reference
The Clionauts
Eric Mauriange (2003) : PAYAGES ET TICE. Des ressources pour enseigner...
http://www.clionautes.org/spip.php?article214

Abstract : This site offers several sites on the use of ICT. For example you will find: landscape Sciences («scientific» knowledge of online teaching). Online university courses; Didactics and Pedagogy landscape (consulting, methodology, examples of application with reflective thinking ...) Resources (Guidelines or resources for progress) and many other exciting aspects. Each site offers resources, but also elements of learning that will be useful in carrying out ecological outings.
Rationale

This site takes you to a wealth of information on teaching practice in terms of educational outings and the approach to landscape using ICT. An excellent website.

Resource 3: Compilation CD of biological images

Abstract: This CD Rom is a bank of images on different levels of biology: molecular, cellular, tissue, organ, organism.

Rationale: The CD ROM is a learning resource. You can use it to illustrate your lessons or to develop content for a formative or a summative evaluation.

List of important links

Link 1

Complete reference: Organizing an outing, preparing a nature class

http://parcours-diversifies.scola.ac-paris.fr/manuel/preparerunstage/pratiques.htm

Abstract

This site provides information on the three stages of an outing ie its preparation, the actual outing and its exploitation. To this end, it establishes a checklist for each step. There is also mention of drafting the outline of a project.

Rationale

With the check-list that is offered, you have a guide to help you better understand educational outings.
Detailed activity description

The biology teachers will attend the educational outings. The activity takes place in three stages: preparation of the outing, the outing itself, and exploitation. In the field, students are divided into groups to perform various tasks: observation of plants and animals, soil characterization, terrain characterization, collection of samples, measurement of temperature, and water properties.

The outing will be a pretext to have the teacher integrate ICT in their lessons and to organize project activities for a database of parks and reserves of the country by the collaborative work of students.

Students are divided into groups of 2 to 5 people (depending on the amount of students enrolled) to research and organize information on the Internet.

- Group 1: Making a herbarium on the main plants of parks and reserves of the country (mangrove, Acacias, ...).
- Group 2: Assembling a compilation of insects and animals characteristic of large parks and reserves of the country.
- Group 3: Working on landscapes and ecosystems, and major constituent of parks and reserves of the country.
- Group 4: Working on regulatory and legal texts relating to parks and reserves of the country (Charter, codes, conventions).

The e-mail accounts are open for students who communicate and share documents and are found in the file in the library of the platform. These documents will be available later on.

The teacher will open a chat and a forum for synchronous and asynchronous communications.
**Details of the activity**

Regarding the three phases of the outing, a checklist is offered through the document «organiser_sortie_pédagogique.pdf» which can be downloaded via the following link.

http://parcours-diversifies.scola.ac paris.fr/manuel/preparerunstage/pratiques.htm

**Preparation of the outing (1 hour).**

- Distribution of students in groups of 2 to 5 people. Group management with a spreadsheet
- Developing an outline of the final report (summary)
- Presentation of instructions (permission from parents of students, apparel, equipment, etc.)

**Outing (3 heures)**

Observing animals
- Guidelines to follow for comments
- Identification of some species
- Instructions for finding information on the Internet

Observing vegetation
- Instructions for comments
- Identification of some species
Exploitation of the outing (4 heures)

### 3.1 Management of students and groups of students. Using a spreadsheet (Excel).

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>e-mail</th>
<th>Level of participation in chat /3</th>
<th>Level of participation in forum /3</th>
<th>Level of participation in report /4</th>
<th>Exercise grade /20</th>
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<td></td>
</tr>
</tbody>
</table>
Researching information on the Internet

- Books deposited in the library: Each individual will file three books and twenty pictures of animals or plants
- Relevance of information.
- Useful links found

Calendar of activities to be consulted by students

<table>
<thead>
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<th>Day</th>
<th>Mois Décembre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>1 8 15</td>
</tr>
<tr>
<td>Tuesday</td>
<td>2 9 16</td>
</tr>
<tr>
<td>Wednesday</td>
<td>3 10 17</td>
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<tr>
<td>Thursday</td>
<td>4 11 18</td>
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<tr>
<td>Friday</td>
<td>5 12 19</td>
</tr>
<tr>
<td>Saturday</td>
<td>6 13 20</td>
</tr>
<tr>
<td>Sunday</td>
<td>7 14 21</td>
</tr>
</tbody>
</table>

Forum: open during the week

Chat: two chats organized during the week

Results

- Developing a database on parks and reserves of the country
- Within each group, there is a division of tasks and levels of responsibilities assigned to group members
- Each group shall select and organize information found.
- Making a virtual database: Sample images online, scan (CT) images that are in books and magazines (pay attention to copyright).
- Production of a reflective report (see instructions in activity 1)
Formative evaluation

Rank the following actions under the headings:

1. Preparation of the outing
2. The outing itself
3. Exploitation of the outing

Group work; measurement factors; means of transport; parental consent; reporting; assessment; safety compliance, information from colleagues, seeking information, administrative authorization, answer students’ questions; adaptation the level of my students, lesson preparation, taking notes, objectives, photos, setting a start time, day chosen. (3 points)

Lists three wishes for the environment that you have visited (2 points).

Write an essay of 300 words or less on an animal, plant or harm to the environment that you have visited (5 points).

Put yourself in the shoes of each of these individuals, and try to express the perception of each (5 points).

Research 5 Internet sites that deal with the educational outing (5 points)
Correct answers

1.
Preparation of the outing         Outing              Exploitation of the outing
transport                         group work         summary
parental authorisation           measure of factors  security respected
subscription                     taking notes        research of complementary information
information of colleagues        answers students' questions
administrative authority         photos
adaptation to students           preparatory lesson
preparatory lesson               fixed objectives
fixed departure time             day chosen

taken notes

2. open question

3. open question

4

Person                          Perception
Fisherman                       Fished all year, ended problems
Farmer                          Irrigation. Security and self-nutrition assured
Prof of SVT                     What a beautiful ecosystem
Physics prof                    There is a method to reduce evaporation and evapotranspiration
Charlatan                       Libations for the whole year
Child                           A natural pool for swimming all year
Nurse                           That explains the high incidence of schistosomiasis
Housewife                       Unlimited water for laundry/drinking
Forester                        Good management benefitting neighboring populations.
Learning activity # 5

Title of the learning activity: Development of analytical tools for animation and simulation in biology

Introduction

ICTs have undoubtedly brought more value in the educational community. Strategies such as animated simulations were developed, and teachers used them more and more. The animated simulation is fantastic, wonderful, and exciting for the learners. But is this a reason for not conducting a thorough reflection on the issue, especially if it is known that the simulation slows or accelerates natural processes, ignoring certain conditions?

In the case of biology, various simulation tools are available on mitosis, cell movement, phagocytosis, the uptake of CO2 by plant growth or action of certain substances on plant development, etc.. Are teachers making an effort to assess the simulation tools? Are they armed for that?

From the use of ICT, teachers’ groups and teachers are asked here to work around a project to develop an evaluation sheet for animation or simulation. Resources are available to them, as well as collaborative tools. The beneficiaries of this activity all have an email address and the training platform offers spaces for collaboration through chat, forum and the library where they can file documents or obtain them.

Specific objectives

Specific knowledge objectives

After the activity, learning and learners will be able to

• recall the different criteria for assessing an animation tool.

Specific method objectives

After learning, the beneficiaries of the training will be able to:

• correctly use an animation tool in their teaching practice;
• to offer, in collaboration with colleagues, an evaluation sheet for animation tools.
Abstract

The teacher develops multiple teaching strategies and uses various methods including the animated simulation. This slows or accelerates a natural fact. It has grown significantly with the computer. The biology teachers integrate it into their teaching practice. Its educational value is high. It allows the learner to form a virtual representation close to reality. This is because factors like time is changed and this is not necessarily obvious to the learner. The teacher must bear in mind the need not to create misconceptions in the minds of children.

Key concepts

Simulation: The animated simulation of a natural phenomenon is a reproductive strategy of a complex phenomenon for scientific, recreational or training purposes.

Animation: setting a process in motion by assembling film still images constituting the course of action.

Chat: a form of synchronous communication in writing using a computer and allowing participants to discuss a given topic

Forum: is a form of asynchronous communication in writing using the resources of a computer where each participant makes a contribution that will be read later by other members.

Collaborative work: It is an activity in which learners perform all work using the tools of distance communication.

Key words

1. Simulation
2. Animation
3. Groupwork
4. Chat
5. Forum
6. E-mail
7. Communication
8. Analysis chart
List of important lectures

Reading 1
Collaborative work: What is Collaborative learning by Barbara Leigh Smith and Jean T. MacGregor

Abstract
This document deals with collaborative learning and provides information on the rationale of educational practice. The collaboration promotes the creation of collective knowledge but also socializes learners. It therefore relies on socio-constructivism. It applies to different learning situations. The approaches are as diverse as the goals and processes.

Rationale
This document is recommended, as there are several situations that may be helpful, particularly in understanding the concepts, applications and strategies.

Reading 2

Complete reference

Abstract
This text parts from simulation software, one on photosynthesis, the other on the electrophysiology of nerve fiber. The paper attempts to situate the use of simulation and comparative advantages with the real experiences before considering the future of practical work. It is a good document. It is critical.

Rationale
This document will guide you in developing criteria for evaluating simulation software.

Complete reference: Simulation in biology
David Leray available at the URL:


Abstract

The author identifies the possible fields of application of the simulation (human biology, ecology, immunology). But it must be said that most of the text focuses on immunology.

Rationale

This document is offered because you will be able to locate the position of simulations in biology, but also take into account certain elements (time, environment) that may fall within the categories of assessment criteria.

List of important resources

Resource 1

Complete reference

Center for Mediated Teaching in Biology
Software used in teaching SVT college or high school
http://www.u-psud.fr/sitesiecle.nsf/logi_col_lyc!OpenPage

Abstract

This site provides a summary of software used in teaching life sciences and earth sciences. All levels of organization are cited: a molecule (DNA), macro (colony of bees, ecosystem). The nature of software is also indicated (tutorial, animation, self evaluation).

Rationale

We offer this site to give you an idea of the wide range is available to teachers. The terms of acquisition or use of software is not specified.
Resource 2

Complete reference
Animation (CD to make from the products available)
Compilation of Mamadou Sarr UCAD / FASTEF

Abstract
This folder contains an animated series in biology (genitals of woman and men; in vitro fertilization) and site where you can find animations on various aspects of life sciences and earth (phenomen of subduction and accretion, greenhouse effect ...).

Rationale
The animations are made by the conceptions and perceptions of the authors. The approaches are necessarily different, even if the standard rules for developing animation or simulation exist. This diversity will help you target your evaluation criteria.
List of important links

Link 1

http://www.snv.jussieu.fr

Abstract.

This site provides the site «in high school biology». Various topics include: theoretical concepts, learning sequences, laboratories, links and various animations such as the penetration of sperm into the oocyte.

Rationale

The animations will help you and help students understand the facts of life that are accelerated. It is important that teachers become aware of this in order to avoid misrepresentation.
Link 2

http://www.biologieenflash.net/sommaire.html

Abstract
This site provides eight (8) animation examples on different areas: movement, function of a ridge (accretion), subduction, plate tectonics, the geological clock.

Rationale
The information provided on this site may be of interest to students, but will also help you define evaluation criteria of animations and simulations.

Link 3

http://www.didier-pol.net/

Abstract
The section «funny biology» of this site presents simple experiments for high school students.

Rationale
This site is recommended because it offers educational tools with easy access.
Description of the activity

The simulation tools used in the teaching / learning in life sciences and earth sciences are all of equal quality. The user must know to make the right choices and how and when to use them.

This learning activity, articulated around the development of an evaluation grid of simulation tools, is organized around five tasks that will eventually achieve the objectives.

Task 1: Required reading of texts on collaboration and simulation. Additional resources and links are also available.

Task 2: Individual analysis of simulation tools available, or take in the sites provided by the tutor or the module designer.

Task 3: Sharing thoughts via internet or a platform: chat, forum

Task 4: Development of an evaluation grid and collective final acceptance of all group members.

Task 5: Report on reflective activity

Each of the tasks will achieve intermediate goals. The beneficiaries of the training are divided into groups of 4 to 5 members. Each individual performs work that they submit to other group members. The various exchanges provided will allow the sharing of knowledge and methods of individual and collective work.

Each participant is asked to reflect on his personal background and performance.

Learning activities

Task 1: Required reading of texts on collaboration and simulation.

Each participant familiarizes themselves with the basic concepts of collaborative work, simulation and communication. It also isolates the criteria and implementation strategies.

Task 2: Individual analysis of simulation tools available, or to take in the sites provided. It is open to the learner to visit other sites on animation and simulations.

Each trainee gets into sites that are communicate 5 simulation tools. He/she observes and analyzes each image using the criteria that they have identified:

- Sequencing of activities: different times? continuous phenomenon? ...
- Time: how is it addressed? shortened? lengthened? variable depending on the importance of sequences ....
- Existence of sub-themes.
• Environment? ...
• Image quality ?.....
• Etc ... .. They will also give their assessment on each image by addressing such issues as follows:
  • Why this simulation is important for its course?
  • How they intend to use it in their course?
  • When will it be used?
  • What are some limitations?

What will the students gain?

Following this, the student will build the first draft individual of the evaluation grid of simulation tools.

Task 3: Sharing thoughts via internet or a platform: chat, forum
Each member sends a file attached by e-mail to to all other group members.
Each member is assessed on each of the grids and sends their comments to all other group members.
Each participant will have all the comments with a second draft of a grid-specific assessment.

Task 4: Development of an evaluation grid and a final group.
As part of a chat or a forum, participants suggest content items of the final grid that will be a synthesis of individual productions. The outcome of this phase is that group members agree on a final grid.

Task 5: Report on reflective activity.
Each group member is developing a reflective report on, among other things, the following points:
• What have I learned? the conceptual, technical, organizational and individual group work, collaboration;
• How did I learn?
• What helped me in my learning?
• How much time did I spend on this activity?
• Am I satisfied with my participation in this collective production?
• What will my new skills change in my own professional activities, including my choices and uses of simulation tools?
• What are the difficulties I have encountered?
• How can I do to pass these skills on to my students?
Formative evaluation

1. Look up 5 definitions of the following words in a virtual dictionary (Encarta), a paper dictionary, encyclopedia and two other sites: Simulation, Animation, Multimedia
Submit a synthetic definition from these definitions
(4 points)

True / False question (1 point)

2. Check the correct answer.
The animation is done on the basis of several images. True / False

3. Research on the Internet (give the URL of the sites) (15 points)
• 3 frames of animation on human reproduction
• 3 frames of animation on the geology
• 3 frames of animation on protozoa
• 3 frames of animation on mitosis
• 3 frames of animation on the ecosystem
Correct answers

1. Open answer
2. True
3. Open answer
Learning activity # 6

Title of the learning activity : Conceptual map and modeling of a food web in an ecosystem.

Introduction

The integration of ICT in teaching and learning must be for the benefit of both teachers and students. Thus, in the spirit of a change in the pedagogical relationship in which the teacher is no longer a companion, and where the student would be the main actor in building their own knowledge, it would be helpful if the former can help the latter to use ICT in their learning. This module has the dual objective of improving the skills of teachers of biology to use ICT in their educational practices and to help students learn with ICT.

Specific activity objectives

Of knowledge

After the activity, the skills acquired by the trainee will help students identify research opportunities in the definition of a concept on the Internet.

Of method

At the end of learning, the trainee will be able to:

• use their ICT skills to help students organize an information search on the Internet;
• model a food web using the tool;
• develop a conceptual map of an ecosystem with a chart plotter.

Abstract of the learning activity

In this activity, the learner takes stock of the various uses of ICT in teaching practice. It includes simple activities that require the students to use computers. The realization of a conceptual map on the ecosystem and modeling of a food web allows the learner to find teaching strategies that can improve student learning with and through computers. In this activity, much will be reserved for collaborative learning. Learners will individually and collectively seek effective strategies to encourage students to integrate the tool in their learning.
Key concepts

Food chain: The food chain can be understood as a set of living creatures linked together in a process of production and consumption of energy and matter in a given ecosystem.

Food Web: a nested set of food chains that connect the bodies of an ecosystem.

Ecosystem: This is the structural and functional unit of the biosphere, and is a group of biological communities coexisting in the same physical environment.

Collaborative work: It is an activity in which learners perform all work using the tools of distance communication.

Key terms

1. Food Chain
2. Food web
3. Ecosystem
4. Modeling
5. Collaborative work
6. Producer
7. Consumer
8. Decomposer

List of important readings for the activity

Text1

(see text in appendix) available through the following link

http://www.univ-ubs.fr/ecologie/trophique.html

Abstract

This document describes the different individuals that make up a food web. It shows that they are autotrophs that produce organic matter, while the movement of matter and energy in an ecosystem is mostly provided by heterotrophic consumers. It reflects the energy losses that occur throughout the food chain and the consequences that it implies.

Rationale

This document, written in a simple style, will be certainly useful for understanding trophic relationships in an ecosystem.
Text 2


Abstract

This paper presents the model of the pelagic production in the Channel. It deals with biogeochemical cycles, particularly nitrogen. In other words, it is to understand how is the transfer of autotrophic food (Diatoms, Dinoflagellates ..) to autotrophic (Mesozooplankton, Microzooplancto).

Rationale

This text offers a model of trophic relationships that can be analyzed as part of a class. This model can help acquire skills in modeling.

Text 3

La zone intertidale ou zone de balancement des marées


Abstract

The document, based on an outing, addresses the marine ecosystem, including living creatures, plants (algae) and animax (mold littorine ..) living in infalittoral floors, inter tidal and supralittoral. In his description, the author makes a classification of species found on site.

Rationale

This text is offered because it contains models of layering of species and relationships with trophic levels. It is rather didactic, as it is the relationship of the results of an outing on the coast.
List of important resources for the activity

Resource 1

Course: Usefulness of biodiversity
http://www.unice.fr/LEML/Francour_Internet/Fichiers_en_ligne/Cours_Utile_Biodiversite.pdf#search=%22Reseau%20trophique%22

Abstract
This paper deals with food webs and biodiversity. Two aspects will be the theme of the text: the importance of biodiversity in a living environment and therefore a decrease in biodiversity. The document contains many curves and models of food webs.

Rationale
This text is readable to complete your information on food webs. It will help you improve your knowledge of the problem of modeling.

Resource 2

Inspiration Software
http://inspiration.demarque.com

Abstract
Inspiration is a software helps design conceptual maps, diagrams, and graphs. It allows the preparation of a presentation.

Rationale
It facilitates the preparation of a presentation and therefore helps to better teach and learn better. You can download it. There are also tutorials.

Resource 3

ThinkGraph
http://www.thinkgraph.com/

Abstract
ThinkGraph is also a 2D drawing software. It can make conceptual maps using a methodical organization of ideas.

Rationale
We recommend you to use this tool, because it will be of great use in your lessons. Your students can also easily master it.
List of important links for the activity

Link 1 : The biodiversity of the reef ecosystem

http://www.ggl.ulaval.ca/personnel/bourque/s4/ecosysteme.recifal.html

Abstract

This site outlines the organisms in a reef. The approach is quite interdisciplinary in that the geological, geomorphological and ecological are taken into account. It crosses these fields but also includes very beautiful images of shellfish and other benthic organisms.

Rationale

This site is worth visiting because it reinforces your mastery of the concept of an ecosystem.
Link 2: Modeling of a marine ecosystem


Abstract
The question is addressed as a very interesting question: How do we develop models? Why use models of an ecosystem?

Results: In the opinion of the author, ecosystem models require the coupling of a biological model and a hydrodynamic model.

Rationale
In this text, already very informative on the academic side, you find elements of simulation on the evolution of chlorophyll concentration based on the time of year.
Link 3 : The biodiversity of an ecosystem


Abstract
This site summarizes the characteristic features of an ecosystem. In some activities, it offers exercises to develop a food chain and multiple-choice questions.

Rationale
The application-based exercises are very interactive.
Detailed activity description

Detailed description of activity

This activity is subdivided into tasks which contribute to achieving the twin goals of improving the skills of teachers of biology, and, secondly, to use ICT in their educational practices to help students learn with and through ICT.

The beneficiaries of the training are divided into groups of 2 to 5 according to the size of the class in order to rotate individual work and collaborative work.

Readings are completed, and consulting resources and links on the subject of study (ecosystem) are available on the one hand, and the teaching strategy (integration of ICT) on the other.

Then, we have the development of a trophic network model and a conceptual map of an individual ecosystem, preceded by an Internet search of images of animals (e.g. lion, vulture, antelope) and plants (grass).

Each recipient sends an email of its production to group members, and receives productions in return from others.

Observations of each other will help to develop a conceptual map accepted by all group members and the adoption of a food web model.

Similarly, each trainee has a procedure to be performed by students of conceptual maps and models using computer tools. A summary of these proposals is developed and shared by members who adopt a final version. Each member produces a reflective report on the work they have done.

Learning activities

The activity is divided into different stages or tasks as follows.

Task 1: Reading and research information

Required reading of texts related to the learning activity and consulting resources, Links and other websites. The task aims to familiarize the recipients of training with computer search tools (Google and other search engines), but also to identify the key concepts (energy, cycle), concepts (food web, food chain) and less important concepts (producer, consumer) to be used in developing the conceptual map on the ecosystem and food web model.

Task 2: Choosing a Model

Selecting a model diagram from the menu «Insert» of the computer, or a software implementation of conceptual maps (Inspiration 7 Trial, ThinkGraph, CmapTools, MindMapper). Focus on free software.
**Task 3: Operation of the model chosen**

Realization of food web models and conceptual maps from the model chosen. Define the meaning of arrows and annotate the production to make unambiguous understanding.

**Task 4: Procedure**

Developing a procedure for modeling and construction of the diagram tool for students. It will be for the learner to list the stages of implementation.

**Task 5: Communication and collaboration**

Exchange on the three individual products (conceptual map, network model, operation mode) and observations of movement between the group members.

**Task 6: Method of transfer of skills**

Learners take ownership of the consensus procedure. The proposed approach will help students and learners to utilize the tool in their learning.
Formative evaluation

Check the correct answer(s).

1. The coastal areas account for 8% of the ocean surface
   - True   - False (0.5 point)

2. Coastal areas provide a quarter of marine carbon
   - True   - False

3. (1.25 points)
The modeling of an ecosystem implies
   - Using a physical model
   - Using a biological model
   - The coupling of a model and a biological model

4. What form (state) is the carbon in a marine ecosystem? (4 pt)

5. Here is a list of words. Organize them into a conceptual map to four entries from the basic concept. (7 points)
   environmental factors, food chain, energy flow, temperature, lake, moisture, land, sunlight, consumer of wind, light, ecosystem, producer, cycle of matter, lion, antelope, decomposer, marine bacterium, functioning, urban, productivity

6. What is eutrophication? (1.25 point)
Correct answers

1. True
2. False
3. The coupling of a model and a biological model
4. State: - inorganic - detritus - benthic organic - phytoplankton
5. See below
6. What is eutrophication?
XV. Synthesis of the Module

Summary of the principles and theories of pedagogical ICT integration

The scientific literature contains a broad range of statements on the principles and theories of ICT integration into instructional practices. This module identifies 28 key principles regrouped into 5 main orientations, each comprising a set of professional competencies to be developed in a teaching/learning context. Accordingly, teachers must be able to:

1- Exercise critical judgment and sensitivity regarding the real benefits and limitations of ICT as teaching and learning resources.

This first orientation includes 5 key principles:

- Vigilance and careful assessment of the impacts of ICT on their students and on their own work
- Alertness to social inequality or exclusion resulting from inability to access resources
- The principle that ICT are not of themselves generators of innovative educational change
- The principle that ICT serve the behaviourist, cognitive, constructive, and instructive approaches equally well
- The principle that ICT should facilitate learning integration and transfer, make learning more meaningful, and help students develop their talents, imagination, resourcefulness, creativity, and the like.

2- Identify and assess the potential of computer software and networking technologies to develop targeted educational competencies.

The 5 key principles stemming from the second orientation are:

- Exploring a number of educational sites to identify appropriate resources in the teacher’s subject area or teaching field
- Maintaining an activity bank to help students with their learning and to support other educational practices
- Assessing resources not designed for instructional purposes and adapting them for the competencies targeted in the study program. Evaluating tools and selecting those that best develop the intellectual and relational competencies argeted. An assessment of the potential of computer software and networking technologies to develop targeted competencies would appear to be critical for achieving educational targets, seeing that many commonly used resources (grammar checkers, Web sites, audiotapes and videotapes, CD-ROMs, etc.) have not been specifically designed for educational purposes.
• Determining instructional needs and equipment requirements and eliminating items that are attractive but of little educational value.
• A thorough analysis of educational software to evaluate the content breakdown, presentation of learning and/or problem-solving steps, tracking reportage, and data handling.

3- **Identify and communicate with a variety of appropriate multimedia resources (e.g., email), collaborative tools to which ICT can make a significant contribution.**

Using ICT effectively, teachers can build networks for information sharing and professional development in their teaching fields and practices, bringing together the work and reflections of individuals with similar interests but from disparate locations. This orientation includes 9 pedagogical principles of effective communication that generate a “collective intelligence”:

• Collaboration, teamwork, joint action, and utilization of the collective intelligence of individuals located at a distance
• The use of thematic, research, peer email, discussion group, databank, image, and sound networks.
• Selection of interactive resources and audiences for specific objectives
• The necessity of establishing selection criteria for professional development resources
• The use of collaborative peer networks to help train new graduates as well as colleagues
• Building networks of teachers who share the same expertise
• Guiding student-directed interactive learning
• Helping students target, formulate, and refine their questions so that ICT information searches are relevant, meaningful and suitable.
• Careful precision in terms of the quality of language used.

4- **Use ICT effectively to search for, interpret, and communicate information and to solve problems**

To better integrate learning resources, the information obtained must be converted into secondary culture (i.e. schooling) objects through the development of knowledge transfer competencies. The use of ICT therefore imposes new demands on teachers’ ways of working: how they structure collective teaching, teamwork, individual work in the classroom, and homework. In this perspective, teachers must adopt 4 essential principles to help students use ICT productively for research and problem solving:

• Targeting of information, and critical analysis and conversion or transformation of useful resources into learning objects for educational activities
• Tracking of students’ progress and interrupting their work as needed
5- Help students familiarize themselves with ICT and use it to carry out learning activities, assess their own use of ICT, and exercise critical judgment toward the information they find on the Internet.

Teachers must also have certain competencies and abilities in order to support student learning with ICT. Accordingly, 5 fundamental pedagogical principles must be applied:

- Developing basic and essential ICT competencies, with an emphasis on computer literacy: introduction to ICT functions and tools (familiarity with common software such as Word, Excel, PowerPoint, etc.) and basic operations (downloading, saving, and filing educational materials, compiling and organizing information).
- Choosing the appropriate tools for a given task, integrating a number of tools to solve actual problems, and using them on an everyday basis in a critical and productive way to serve as a model for the students.
- Using a diversity of ICT software to teach, learn, communicate, and solve problems in different subjects, and adopting clearly expressed, critical stance toward these technologies.
- Developing projects and the accompanying documentation (e.g., worksheets, digital portfolio) that integrate various aspects of the course content and extend the meaning of the information beyond the classroom.
- Evaluating the learning achieved through specific questions, effective work processes (e.g., integrated online self-evaluative learning, access to glossaries and extra class notes at Internet-accessible hypertext sites, etc.) The following figure illustrates the main orientations of the key pedagogical principles of ICT integration.
Learners should be able, through this module, to identify the key-concepts in the process of ICT integration, and to critically engage the required readings and resources (an important skill in Open and distance learning). Examples of learning activities, which can be modified to suit specific disciplines, are provided, as are a number of useful links (illustrated with screen captures), the latter presenting pedagogical resources and serve to guide educators and learners in their knowledge-seeking and training processes. A bibliography is provided to further support techno-pedagogical skills, facilitate research, lesson planning, teaching, problem-solving, professional development, and most importantly to enhance student’s learning through ICT.
Synthesis specific to teaching and learning of biology

In the field of biology, this module allows learners to familiarize themselves with the key concepts of biology of both animals and vegetation, but also the ecology. The learning activities offered help to initiate collaborative work and to have the skills in information retrieval for a defined project. What is especially interesting in this unit is that it helps to teach better and discipline in a socio-constructivist approach.

This module use of ICT in biology revolves around three main axes, namely:

1. Identification of areas of ICT use in biology;
2. Development of collaborative work both in solving problems and in other learning situations;
3. Research and information synthesis.

The first axis is taken into account in the activity of module 3. Virtually all activities developed in classroom are achievable in distance education. Even if work practices are supported by software simulation. The nature of activities (such as administrative transcript) teaching (drawing and annotation, production experience, evaluation) can be implemented and managed by distance learning through ICT.

Compared to the second axis, the module provides several sequences that work together. Achievement of tasks proposed and the reflective work that is requested at the end of each learning activity will help you self-evaluate and enhance your critical potential.

Regarding the search for information in Internet, it lies at the heart of all learning activities proposed.
XVI. Summative Evaluation

**True / False**
Check the correct answer

1. The ovaries have an anatomical bond with the fallopian tubes.
   - True □ False ■

2. Progesterone is responsible for the proliferation of the endometrium and secretion of mucus.
   - True □ False ■

3. The Caryopycnotic index measures the number of dead cells in vaginal
   - True □ False ■

4. The primary follicles appear at puberty.
   - True □ False ■

5. Testosterone is a hormone soluble in water
   - True □ False ■

   - True □ False ■

7. The ovary begins to form from the twentieth week of embryonic life.
   - True □ False ■

8. Testicular temperature is lower than that of the body.
   - True □ False ■

9. The placenta provides the synthesis of hormones responsible for the maintenance of pregnancy.
   - True □ False ■

10. Estrogens have a pre-ovulatory peak around 16 hours before ovulation.
    - True □ False ■
Multiple choice questions

Check the correct answer

11. ovulation rate is:
   - the number of oocytes released at the same time
   - the number of oocytes possessed by a woman
   - the number of eggs fertilized during the life of a woman

12. Autocrine action is:
   - stimulation of the secretory cell itself
   - stimulation of neighboring cells without transport by blood
   - stimulation of cells with transport by the blood

13. GnRH secretion in adult men is rhythmic and has:
   - a peak every 40 minutes
   - a peak every 50 minutes
   - a peak every 80 minutes
   - a peak every 90 minutes (P16)

14. LH stimulates:
   - Sertoli cells
   - Leydig cells
   - follicular cells

15. The pH of the mucus of the cervix during the ovulatory phase is:
   - pH = 5
   - pH = 7, 8
   - pH = 6, 2

16. During implantation,
   - the morula enters the mucosa
   - the blastocyst enters the mucosa
   - the fetus enters the mucosa

17. Which of these hormones prevents the loss of the corpus luteum during the embryonic phase
   - LH
   - FSH
   - chronic gonadotropin hormone HCG
18. Vocabulary
What is another name for:
- Muscularis uterine
- Pouch
- Follicular cavities
- Rod
- Castration

19. What are the four functions of the ovary?

20. What are the functions of the testicle?

21. The diatoms are part of microzooplankton
- True
- False

22. Barnacles live on which floor?
- Supra-littoral
- Mid-coast
- Infra-littoral

23. The regime of an animal can sometimes change during its life
- True
- False

24.
- Number the living organisms
- Determine the number of trophic levels
- Place each living organism in its trophic level
- Put the living organisms in a food web
True /False

25. The approach «application» is classified in the model stages of teaching and learning.
   ☐ True ☐ False

26. The process of integration of ICT is iterative.
   ☐ True ☐ False

27. Multiple choice question. Check the correct answer ICT means
   ☐ - information technique and communication
   ☐ - computer technology and communication
   ☐ - computer technology and communication
   ☐ - Information Technology and Communication
   ☐ - techno-information and communication

28. List the four phases of the continuum model approach to ICT development
Correct answers

**True / False**

1. False
2. False
3. True
4. True
5. False
6. False
7. False
8. True
9. True
10. False

**Multiple choice**

11. Ovulation rate is the number of oocytes released at the same time
12. An action is autocrine stimulation of the secretory cell itself
13. GnRH secretion in adult men is rhythmic and has a peak every 90 minutes (P16)
14. LH stimulates the Leydig cells
15. The pH of the mucus of the cervix during the ovulatory phase is pH = 7, 8
16. During implantation, the blastocyst enters the mucosa
17. The hormone that prevents the disappearance of the corpus luteum during the embryonic phase is HCG (chronic gonadotropin hormone)

18. Vocabulary
   - Muscularis uterine = myometrium
   - Pouch = scrotum
   - Follicular cavities = antrum
   - Rod = penis
   - Castration = capon

19. The four functions of the ovary are: oogenesis, folliculogenesis, ovulation and endocrine function.

20. The functions of the testis are spermatogenesis and endocrine function.
21. False
22. Inter tidal
23. True
24.

25. False
26. True
27. Information Technology and Communication
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## XVIII. Scorecard

### ICT Integration in Biology

**Professor Mamadou Sarr**  
Academic year 2005-2006

### Evaluation sheet

<table>
<thead>
<tr>
<th>First name</th>
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Summary sheet of student’s grades.
XIX. Main Author of the Module-ICT Integration in Biology

Author of the Module - Conceptual framework

Salomon Tchameni Ngamo is the author of the introductory, conceptual framework, portion of this module. He studied Classics in his home country of Cameroon. In the four years since his MA in Education from Université de Montréal in Canada, he has developed expertise in the pedagogical integration of ICT. With a combined 15 years teaching experience in Africa, after winning an excellence prize during his own training, he is a department head at The National Institute of Youth and Sport in Cameroon, where he also instructs. In addition to his own research, he has co-authored course syllabi and research guides. As a research professional at the Canada Research Chair on Information and Communication Technology (ICT) in Education he coordinates joint Université de Montréal/ER-NWACA transnational research projects on ICT integration in Education in West and Central Africa. Also an online teaching assistant, he is responsible for several cohorts of African students in the Université de Montréal/UNESCO/l’Agence Universitaire de la Francophonie distance learning micro-programs. Most recently, Salomon Tehameni Ngamo’s expertise is being put into action in the development of Université de Montréal’s first distance education PhD offering, while he is also finishing his own PhD thesis in Pedagopsychology.

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Sarr holds a doctorate new thesis from the University Paris 7 (France) in Science Teaching Option biology and education on the environment.

After teaching in various schools of Senegal, Mr. Sarr was hired as a teacher researcher at the Ecole Normale Superieure in Dakar became Faculty of Science and Technology Education and Training (FASTEF). It was respondent PMP2 (multi-partner project): Master of remote environment, the PMP 32 «international courses offered through distance Environmental International CAERENAD (Application Center, studies and resources in distance education) involving six universities in six countries: Brazil, Chile, Costa Rica, Mauritius, Quebec, Senegal. Participant PMP 52: Virtual Labs. He has participated in various workshops «Transfer» in the Regional Office in West Africa of the Agence Universitaire de la Francophonie (AUF), which is a member of the steering committee in distance education.

He trained as a Master in International e-learning program Cosel learn, Swiss project interesting 50 universities in the southern Sahara. Sarr is author of several publications and works.
BIOLOGY 2: ICT INTEGRATION IN TEACHING AND LEARNING BIOLOGY

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Information and communication technologies

**Information and Communication Technology** or **ICTs**[^1] allow users to participate in a rapidly changing world in which work and other activities are increasingly transformed by access to varied and developing technologies.

ICT tools can be used to find, explore, analyze, exchange and present information responsibly and without discrimination. ICT can be employed to give users quick access to ideas and experiences from a wide range of people, communities and cultures.

[] Economic Impacts

In recent decades widespread incorporation of ICTs into many tiers of business, political processes and eructuring of the global economy. ICTs have increased international interconnectedness and speed up the process of globalization. They have been instrumental in the information revolution, facilitating the transition from industrial economies, driven by the manufacturing sector, to knowledge economies[^2].

ICTs, in conjunction with globalization and the information revolution, have reshaped the workforce. By increasing the speed of international communication, ICTs have enabled corporations to outsource jobs, both in the manufacturing as well as white collar sectors[^3]. While this lowers production costs and, as a result, the cost of goods, it has also had fundamental and often detrimental impacts on labour conditions.

Outsourcing causes geographic fragmentation of commodity chains, in which production of goods occurs in specialized plants in different locations, often traversing international boundaries[^4]. Locations with no or minimal restrictions on wages, compensation and entitlements for workers therefore become economically attractive as sites of production. This can lead to the exploitation of workers in developing countries and undermine the bargaining power of organized labour in developed countries[^5]. Outsourcing causes geographic fragmentation in which production of goods occur in specialist plants, often traversing international boundaries.

Despite the international spread of ICTs, the economic impacts have been geographically uneven. They have exacerbated pre-existing disparities between developed countries, which can afford to produce and consume the latest technologies, and developing countries, which cannot. This gap is known as the digital divide[^6].

[] Social Impacts

[^1]: [Information and communication technology](https://en.wikipedia.org/wiki/Information_and_communication_technology)
[^3]: [Outsourcing](https://en.wikipedia.org/wiki/Outsourcing)
[^5]: [Digital divide](https://en.wikipedia.org/wiki/Digital_divide)
ICTs have impacted societies on many levels. They have extended the reach of public administration, leading to a centralization of regional management into urban centres\[7\].

They have led to new forms of employment in innovation and production of ICTs and a demand for highly-skilled specialists\[8\]. However, ICTs have also enabled professionals in certain industries to be replaced by unskilled workers, or even made entirely redundant\[9\]. Proponents of ICTs portray this as a ‘re-skilling’ of the workforce, while to detractors it is a ‘de-skilling’ process\[10\].

The diffusion of ICTs within societies is varied, with some institutions and sections of society having greater access to ICTs than others. These divisions are reflected in the content of ICTs. For example the English language, which is understood by only 10% of the world's population, accounts for approximately 80% of internet content\[11\].

Despite these imbalance in power relations, many social justice movements believe ICTs can be used to promote equality and empower marginalized groups. These groups advocate ICTs as a means of providing accessible and affordable information and as a platform for voices that might otherwise go unheard\[12\].

\[ Economic development \]

ICTs have been identified by many international development institutions as a crucial element in developing the world's poorest countries, by integrating them into the global economy and by making global markets more accessible. The World Bank has collaborated with the International Finance Corporation to promote access to ICTs, an initiative which it describes as one of its most successful\[13\]. In 2006 the United Nations launched an initiative called the Global Alliance for Information and Communication Technologies and Development.

\[ Information and communication technologies in education \]
Information and communication technologies in education deal with the use of Information and Communication Technologies (ICTs) within educational technology.

[] Purpose

The purpose of ICT in education is generally to familiarise students with the use and workings of computers, and related social and ethical issues.

ICT has also enabled learning through multiple intelligence as ICT has introduced learning through simulation games; this enables active learning through all senses

[] ICT By country

[] Australia

In all of Australia, ICT is not a subject until the final two years of schooling, despite similar subjects being available before VCE or equivalent. In Victoria, children start ICT in Prep but are not reported upon until they are in Year 1. They undertake a wide range of activities using technology to learn in all curriculum areas.[1]

[] Norway
Norway ICT is a course which students can select for their second year of upper secondary school. From pre-school to Year 10 ICT is interwoven throughout the curriculum as part of the Essential Learning of Communication.

[ ] Philippines

Other countries, such as the Philippines, also have ICT as an educational subject in their curriculum.

[ ] United Kingdom

In the United Kingdom, Information and Communication Technology (ICT) is a subject in education, and a part of the National Curriculum. All students must study Information and Communication Technology to GCSE level.

The ICT programme in the United Kingdom is co-ordinated by Becta. A major initiative was the Curriculum Online scheme, which was closed in 2008 and which was produced to accelerate the uptake of technology amongst schools. Becta took over the running of this scheme from the Department for Education and Skills in 2005. Becta worked closely with the Joint Information Systems Committee to develop strategy.

Students are taught to use software such as office suites, desktop publishers; they are also taught about ICT theory, and how ICT can be used to solve problems. Computer programming is not taught at GCSE level.

Students also study the Data Protection Act, the Computer Misuse Act, and other legal and ethical issues related to ICT.

Many schools have specialist school status in technology and, more recently, in maths and computing, and these schools champion the use of ICT to enhance teaching and learning.

Within Scotland and the North East of England a pilot enterprise in education initiative[2] aims to use ICT as a vehicle to encourage creative thinking within the youth demographic. Tapping into the 'unconstrained' minds of the regions young people, the programme simulates the process of taking a new innovative ICT idea through the commercialisation process. The competition is sponsored by Microsoft and BT and hopes to expand its reach throughout the UK in 2009/10.

[ ] Categories

ICT in education can be broadly categorized in the following ways:

- ICT as a subject (i.e., computer studies)
- ICT as a tool to support traditional subjects (i.e., computer-based learning, presentation, research)
- ICT as an administrative tool (i.e., education management information systems/EMIS)
Biology inspires perceptive machines

Teaching a machine to sense its environment is one of the most intractable problems of computer science, but one European project is looking to nature for help in cracking the conundrum. It combined streams of sensory data to produce an adaptive, composite impression of surroundings in near real-time.

The team brought together electronic engineers, computer scientists, neuroscientists, physicists, and biologists. It looked at basic neural models for perception and then sought to replicate aspects of these in silicon.

"The objective was to study sensory fusion in biological systems and then translate that knowledge into the creation of intelligent computational machines," says Martin McGinnity, Professor of Intelligent Systems Engineering and Director of the Intelligent Systems Engineering Laboratory (ISEL) at the University of Ulster's Magee Campus and coordinator of the Future and Emerging Technologies (FET) initiative-funded SENSEMAKER project of the IST programme.

SENSEMAKER took its inspiration from nature by trying to replicate aspects of the brain's neural processes, which capture sensory data from eyes, ears and touch, and then combines these senses to present a whole picture of the scene or its environment. For example, sight can identify a kiwi, but touch can help tell if that kiwi is ripe, unripe or over-ripe.

What's more, if one sense is damaged, or if a sensory function is lost due to environmental factors, say because it can't see in the dark, the brain switches more resources to other senses, such as hearing or touch. Suddenly those faculties become comparatively hypersensitive. When it goes dark the brain pours resources into these two senses, along with hearing and smell, to extract the maximum possible data from the environment.

Modelling human perception

To explore these aspects of biological perception SENSEMAKER first developed a model of human perception, based on the best available data from the biological and neurological sciences.

Biological neurons use short and sudden increases in voltage to send information. These signals are more commonly known as action potentials, spikes or pulses. Computer science calls the phenomenon Spiking Neural Networks. More traditional or classical artificial neural networks use a simpler model. "The traditional model of an artificial neural network is quite removed from biological neurons, while the spiking neural networks we used are more faithful to what happens in the real biological brain," says Professor McGinnity.
Similarly, adaptation is another aspect of the biological model, known as plasticity, where data flows through new routes in the brain to add further resources to data capture. If repeated over time, this plasticity becomes learning, where well-travelled routes through the brain become established and reinforce the information that passes.

As the model was being established, the team developed hardware demonstrators to implement and test components of the overall sensory fusion system. One project partner, the Ruprecht Karl Universitaet in Heidelberg, focused on implementations based on classical traditional neural networks – essentially large arrays of simple threshold devices. In parallel the ISEL group used Field Programmable Gate Arrays (FPGAs) to implement large arrays of spiking neural networks for emulation of a number of components of the sensory system, particularly the visual processing element.

"FPGAs are hardware computing platforms that can be dynamically reconfigured and as such, are ideal for exploring artificial representations of biological neurons, since their ability to reconfigure can be exploited, to some extent to mimic the plasticity of biological networks of neurons," says Professor McGinnity.

**Biologically-plausible hardware implementations**

Spiking neurons are more biologically compatible compared to traditional classical neural networks, such as the McCulloch-Pitts threshold neuron, because the time between spikes and their cumulative effect determine when the neuron fires. By using an advanced FPGA computing platform, ISEL were able to implement large networks of spiking neurons and synapses, and test the biological approaches for sensory fusion. The FPGA approach allows for flexibility, both in terms of rapid prototyping and the ease with which different neuron models can be implemented and tested.

However, dedicated analogue or mixed analogue-digital circuitry allows for greater integration and lower power operations. To exploit these properties, the Heidelberg group developed a spiking neuron Application Specific Integrated Circuit device, so as to be able to emulate larger constituent components of biological sensory systems. A prototype device had been submitted for fabrication when the project completed, but when fabricated will be exploited in a follow-up European project.

These circuits process data in a similar manner to the biological brain, focusing resources on the most data-rich sensory stream. A user interface on a PC lets researchers engage with the system.

The team concentrated on two particular senses, namely sight and touch. The experimental touch-sensor system, developed in Heidelberg and used by the SENSEMAKER partner Trinity College, Dublin, is itself quite novel. It features an array of small, moveable spring-loaded pins. This enabled psychophysical experiments on touch and vision to be conducted on humans and was a very valuable tool in exploring human responses to sensory integration. The results from these experiments helped to inform the sensory fusion model.
Modelling sensory fusion

The project has created a sophisticated, biologically-inspired model of sensory fusion, for tactile and visual senses. Perhaps the greatest achievement of the project is the creation of a framework which allows extensive experimentation in terms of sensory integration. The project’s work can easily be extended into other sensory modalities; for example the project partners are currently planning to extend the work to auditory senses. The hardware implementation(s) of the model, which allow for extremely rapid learning as compared to biological timescales, will be exploited in follow-up projects.

"Using these systems we were able to show that the merging of tactile and visual information, or sensory fusion, improved overall performance," says Professor McGinnity. The ultimate outcome of this type of research is to implement perception capabilities in computer systems, with applications in a wide range of areas including robotics.

But a greater understanding of biological sensory fusion, and how to implement it in artificial systems, could do potentially much more.

"This type of research teaches us a lot about how biological systems work, and it could lead to new ways of treating people with sensory-related disabilities, though that kind of outcome will take a long time," says Professor McGinnity.

He says intelligent systems need to adapt to their environment without reprogramming; they need to be able to react autonomously in a manner that humans would describe as intelligent; for that they need a perception system that enables them to be aware of their surroundings.

Two other projects will carry aspects of their work further. The FACETS project, also funded by FET will continue to explore machine perception, focusing on vision. Meanwhile ISEL at Magee Campus is actively engaged in a major proposal to create a Centre of Excellence in Intelligent Systems. The Centre will progress a range of research problems related to the creation of intelligent systems, including sensory fusion, learning, adaptation, self-organisation, the implementation of large-scale biological neural sub-systems in hardware and distributed computational intelligence.

The SENSEMAKER project is an excellent example of the integration of a multidisciplinary team, combining basic science with very advanced engineering. Projects involving multidisciplinary teams are challenging, but when they work well can be extremely rewarding. Each discipline brings its own particular expertise, experimental approach, technical language, viewpoint, and problem solving technique to the discussions. This rich mix of knowledge and methodologies allows for exhilarating technical discussions and leads to approaches being adopted that would not otherwise have been considered.

In the case of SENSEMAKER, this was certainly the case – as well as the concrete technical benefits, the project has brought to the team’s biologists and neuroscientists a greater knowledge and understanding of the engineering approach to problem solving and system design; conversely the engineers on the team benefited from a vastly improved insight into the world of
biological system modelling. Overall the project has contributed to an improved understanding of how biological systems merge multimodal sensory information. This is one of the most difficult problems in science today; the results of the SENSEMAKER project are being disseminated in high quality international journals, reflecting the fact that the research performed in this project is at the state-of-the-art. Both biological and neurological science on the one hand, and machine intelligence and computer science on the other have benefited from its successful conclusion.

ICT INTEGRATION INTO EDUCATION:

A CASE STUDY OF SINGAPORE

Component 1: Broader Environmental Context

Issue 1: Responsiveness of the Educational System

Analysis of Strategies

Literacy has improved slowly and steadily in the last four decades, in tandem with the upgrading of the educational level of Singapore residents. The general literacy rate among the resident population aged 15 years and over increased from 60.2% in 1965 to 93.2% in 2001. The percentage of Primary one cohort that has entered the polytechnics and universities has also increased to a high of 60% in 2000 (i.e., very high by international standards). Although compulsory education was not implemented until 2003\(^1\), Singapore has achieved almost universal education at the primary and the secondary levels through years of effort. The success of the education system has also been evident based on many international comparative studies and reports. For example, in the Third International Mathematics and Science Study (TIMSS) in 1996, Singapore’s 12- and 13-year old students were ranked first in this major cross-national investigation. Since then, the Mathematics curriculum of Singapore has become an item of interest to education systems internationally. Another example is the report in the September 1997 issue of Times Education Supplement that stated “Singapore is currently seen as the most academically successful nation in the world”.

\(^1\) Compulsory education is until Primary six as it is considered the minimum period of education for all Singaporean children.
Such successes are attributed to the pragmatic and well-planned approach adopted by the government to improve the education system to ensure the success and sustainability of her economy (Gopinathan, 2001). Since self-government, education in Singapore has always played a dual role of supporting economic growth and promoting social integration. These two objectives that have been formulated in the 1960s are still relevant today. With globalization, it is critical to educate the young to be global players with a strong foundation of knowledge and skills for lifelong learning, but without losing their sense of belonging to Singapore (Ministry of Education, 2000). The government provides enough places for all school-aged children in national schools. These places are heavily subsidized by the State.

The Ministry of Education (MOE) is the main organization that oversees the curriculum, educational structures, examinations, teacher qualifications and fitness to teach, and conditions of service. There have been many major educational policy initiatives in Singapore since the 1970s: the introduction of ability streaming at primary school level proposed in 1979, the establishment of the first ethnic self-help (education) group Mendaki in 1981, the establishment of independent schools in 1988, the provision of ten years of general education as recommended in 1991, the implementation of the Masterplan for ICT in Education, and launching of the vision of “Thinking Schools, Learning Nation” in 1997. Under the vision, the MOE has shifted away from an efficiency-driven education towards an ability-driven one that aims to develop and harness the abilities and potential of every child.

An ability-driven education approach requires a responsive education structure, the creation of a student-centered learning environment, the inculcation of values and nurturing of thinking skills and creativity through the formal and informal curricula, and the building of a quality teaching service. Teaching and assessment methods have been reviewed and modified to nurture thinking skills and creativity, and to encourage knowledge generation and application. At the same time, citizenship education (through the infusion of National Education into the curriculum), character building (through participation in co-curricular activities), and inculcation of moral values (through both Civics and Moral Education, and co-curricular activities) have been re-emphasized. In the context of this case study, ICT is perceived as a mediating tool for many of these processes in the education system. The Masterplan for ICT (MP1), then, is well-situated and supported within such a system.

Lessons Learned and Recommendations

- The ICT Masterplan should ideally be situated in an education system that is well-planned. Such a system supports and facilitates the successful implementation of the Masterplan.
- ICT must be perceived and used as a mediating tool to meet educational objectives in schools. Such an approach is crucial to ensure that the Masterplan is education-driven and not technology-driven.
- The ICT Masterplan should not be a stand-alone policy with little connection to other educational policies or initiatives. In the case of Singapore, MP1 was implemented in the same year as the launching of the vision of “Thinking Schools, Learning Nation”. With a clear and common vision, education stakeholders were in a good position to examine the opportunities of ICT in the education system.
- For the ICT Masterplan to be successful, the education system should be responsive to the introduction of ICT into the teaching and learning processes. When ICT is employed in
schools, there is a need to review and modify existing teaching, learning and assessment practices.

- In order for the opportunities of ICT in education to be optimized, the education system has to move towards a more student-centred and ability-driven one.

**Issue 2: Masterplan for ICT in Education and ICT Infrastructure**

**Analysis of Strategies**

In Singapore, the Masterplan for ICT (MP1) in Education was launched in April 1997 and had clearly spelt out how ICT was to be used and integrated in education as a strategy to meet the challenges of the future. As part of this plan, all Singapore schools were expected to acquire and integrate ICT in their curriculum so as to develop a culture of thinking, lifelong learning and social responsibility. The Educational Technology Division (ETD) of MOE is responsible for facilitating the conceptualization and implementation of the five-year ICT Master Plan (see [http://www1.moe.edu.sg/iteducation/](http://www1.moe.edu.sg/iteducation/)). The blueprint for MP1 consisted of four main goals:

- Enhance linkages between the school and the world around it, so as to expand and enrich the learning environment.
- Encourage creative thinking, lifelong learning and social responsibility.
- Generate innovative processes in education.
- Promote administrative and management excellence in the education system.

These goals will be elaborated in greater detail under Issue 2 of Component 2.

To meet these goals, four key dimensions of the ICT masterplan were identified. They included curriculum and assessment, learning resources, teacher development, and physical and technological infrastructure. This section focuses on the physical and technological infrastructure. MP1 set out national standards for ICT infrastructure by the year 2002 as a guideline for schools. It envisaged that by 2002, students would spend up to 30% of curriculum time using ICT. To achieve this, a student-computer ratio of 2:1 was targeted for every school by 2002. All primary schools were initially provided with a student-computer ratio of 6.6:1 so as to achieve ICT-based learning for 10% of curriculum time. Secondary schools and junior colleges were given an initial student-computer ratio of 5:1, enabling ICT to be used for 14% of curriculum time.

Students were also provided with access to ICT in all learning areas of the school. Computers were provided in classrooms and other learning areas such as libraries and special rooms, besides computer laboratories. This allowed for more effective integration of ICT throughout the curriculum, and allowed for its use both during and after curriculum hours. The use of notebook computers in classrooms, with their advantages of size and portability, was an option that some schools employed. Notebooks would overcome constraints of space, give flexibility in the
arrangement of students for group learning, and might enable higher utilization of computers through their deployment to different classes at different times.

MP1 provided for a teacher-notebook ratio of 2:1 in every school. Schools could deploy their notebooks flexibly, so as to ensure maximum utilization by teachers and appropriate use during and after school hours. Notebook computers were provided to teachers to work around the constraints of space in staff rooms and the need for portability - both within the school and to enable teachers to work at home. MOE also provided grants for teachers to purchase their own computers, so as to promote the use of the computer as a personal tool for every teacher. Under this computer purchase scheme for teachers, MOE co-paid either 30% (for desktop computers) or 40% (for notebook computers) of the cost of computers purchased by teachers, including vice principals and principals. The scheme covered the computer (including self-assembled), modem, printer and MS Office.

MP1 provided for whole-school networking in every school. It allowed courseware, the Internet and digitized media resources to be accessed in every classroom and in all learning areas. Networking also allowed for sharing of teaching resources within and between schools. All schools were linked through a Wide Area Network (WAN), which were eventually connected to the high-speed backbone of Singapore ONE. All teachers and students from Primary four and above were provided with email accounts. Additional physical infrastructure with respect to power, space and furniture required for an ICT-enriched school environment were incorporated into future school building specifications.

**Lessons Learned and Recommendations**

- The national ICT policy must be driven by a vision that can be operationalized into realistic and manageable goals.
- A holistic approach must be taken towards the national ICT policy in education; in the case of MP1, four dimensions were identified - curriculum and assessment, learning resources, teacher development, and physical and technological infrastructure.
- There should be a division in the MOE that is responsible for coordinating and implementing the ICT Masterplan in education.
- A good physical and technological infrastructure is a necessary condition for effective ICT integration. Many researchers had identified that the most frequently mentioned problem of integrating ICT in education was the insufficient number of computers (Cheung, 1997; Williams, Coles, Wilson, Richardson, & Tuson, 2000; Pelgrum, 2001).
- ICT is an essential work tool of the teacher. Teachers must have ready and frequent access to ICT both during and after curriculum hours, so as to access information and learning resources; prepare lesson plans; deliver their lessons; assign work and respond to their students’ scripts and projects; communicate with their peers and supervisors; and perform administrative tasks. The effort of putting technology into the hands of teachers was being carried out in many countries. In the report for the British Educational Communications and Technology Agency (BECTA), Wood (1998) stated:
  
  Research figures for the scheme (where selected IT-novice teachers were given their own portable computer) show a dramatic increase in the participant teachers’ use of IT: over 90% successfully used CD-ROMs. 76% successfully used the
Internet and 95% used the portable at home and at school for planning and delivering their teaching

- ICT should be placed in all teaching, learning, and even play areas in the school. This encourages the use of ICT both within and outside curriculum time, making ICT an integral part of all activities in school.
- Mobile computing offers schools many opportunities that include overcoming constraints of space and giving flexibility in anytime-anywhere utilization of ICT in schools.
- The advantages of networking of schools go beyond access to the Internet. They also include sharing of resources and collaboration within the school, among schools, and with other organizations.

### Issue 3: Economic Context: Towards a Knowledge-Based Economy

#### Analysis of Strategies

In the face of intense competition from other emerging Asian economies, Singapore can no longer rely on the accumulation of capital and labor to sustain economic growth. She has to redefine herself to remain competitive, and this involves moving towards more value-added industries that produce high-tech and knowledge-intensive products. The formation of the National Science and Technology Board in 1991 marked a milestone in a deliberate government policy to promote the development of science and technology (S&T) in Singapore. Together with the comprehensive and responsive education system that has progressively improved the skill sets of the country’s labor force, Singapore is building up her Knowledge-Based Economy (KBE). The key characteristics of a KBE are summarized by APEC (2000) as “an economy in which the production, distribution, and use of knowledge is the main driver of growth, wealth creation and employment across all industries”.

Although Singapore’s KBE is generally competitive with the OECD countries, it has so far relied mainly on knowledge acquisition as the source of competitive advantage to drive her KBE. Her strong knowledge acquisition capability has been a result of her industrial policy of attracting multi-national corporations (MNCs), openness of business environment, as well as excellent ICT infrastructure. Knowledge acquisition will continue to grow and remain Singapore’s main source of new knowledge in the medium term. However, in order to sustain economic growth in the long term, Singapore will need to position her national policies to nurture a more broad-based KBE to sustain economic growth. These efforts include enhancing her national innovative system, entrepreneurship and education capability (Toh, Tang, & Choo, 2002).

This section focuses on enhancing the education capability of Singapore to upgrade the workforce’s capacity to generate new knowledge and make her the knowledge hub in the region and beyond. In the short to medium term, a three-tier system suggested by the ERC Working Group on Education included:
Universities to provide a broader tertiary education base as well as cater to specialized niches;
- A core of quality commercial schools to foster on-the-job upgrading; and
- MNCs to set up regional training facilities in Singapore (Toh et. al, 2002).

However, in the long run, the school system is the one that lays the basic foundation and dispositions of the workforce that is capable of creating, acquiring, disseminating and applying knowledge.

The primary motivation for integrating ICT in schools is the belief that it supports students in their own constructive thinking, allows them to transcend their cognitive limitations, and engages them in cognitive operations that they may not have been capable of otherwise. Most Asian countries have channelled many resource into the development of ICT to ensure that their workforce is competitive regionally and globally. Singapore is no exception. MP1 has done well in promoting and facilitating the integration of ICT in schools. In 2002, the MOE further elaborated upon the goals of MP1 (called MP2) in order to focus on the learner, school capacity and leadership and active research in ICT-based teaching and learning. These goals are elaborated upon in a later section. Under MP2, ICT is perceived as a key enabler in the teaching and learning process. Both ICT masterplans are responses to prepare students to meet the future needs of the KBE.

**Lessons Learned and Recommendations**
- The goals of the ICT Masterplans in education should be consistent with the goals of the economy. The drive towards the KBE calls for a responsive education system that will prepare the workforce for creating, acquiring, disseminating and applying knowledge. The ICT Masterplans have responded effectively and quickly to the future needs of the KBE.
- A highly developed ICT infrastructure in the economy is necessary to facilitate the successful implementation of the ICT Masterplan in schools.
- The ICT Masterplan in schools is only one of the key economic strategies to build a KBE. Therefore, this strategy should not be formulated in isolation. It should be planned and implemented to complement and support the other strategies, such as enhancing Singapore’s national innovative system and entrepreneurship.
- Moreover, ICT masterplan in schools is only one of the key efforts to enhance the education capability of Singapore. Its main role is to lay the basic foundation and dispositions among students to learn how to seek out new information, think critically and show initiative to meet the challenges of a fast-changing world.

**Component 2: Policy and Regulatory Environment (National, sub-national, school levels)**
Issue 1: Policy development: Pre-Masterplan of ICT in Education

Analysis of Strategies
In 1982, the Civil Service Computerization Program (CSCP) was launched to spearhead the national computerization effort and establish the pace for ICT application in Singapore. This was followed by the National IT Plan (NITP) in which the National Computer Board (NCB) outlined a seven-pronged approach to ICT strategy in Singapore: development of ICT professionals and experts; improvements to the information communication infrastructure; promotion of the ICT industry; co-ordination and collaboration between various ICT-promoting organizations; establishing a culture that welcomes ICT; encouraging creativity and entrepreneurship; and increasing ICT application in the workplace (National Computer Board, 1986). To offer greater concentration on these ICT-related approaches, the education system underwent some major changes. At the tertiary level, the polytechnics and universities were oriented towards ICT-related training; at the secondary and primary levels, the system was restructured away from the British system to incorporate features of a German system, such as training in mathematical and technical competencies. Computer awareness programs were also introduced in schools (Low, Soon, & Toh, 1991).

The current phase of ICT initiatives began in 1991 with the launch of the IT2000 Masterplan. Singapore is to be transformed into an intelligent island, where ICT permeates every aspect of the society – at home, work and play. ICT was first piloted by the MOE as a tool to assist students’ learning with the introduction of Accelerating the Use of ICT in Primary schools (AICTP). The AITP project, implemented in 6 pilot-schools in mid-1995, introduced multimedia teaching in key subjects at the primary level. Students in the pilot schools spent about 10% of curriculum time using ICT. The evaluation of the pilot schools has found the program helped most pupils in their learning. The more academically-inclined students have used ICT to go beyond curricula objectives and have become more independent learners, while the less academically-inclined ones have shown greater interest in their studies, encouraged by hands-on lessons, and were able to attain the curricula objectives.

The Student's and Teacher's Workbench (STW) was implemented in six pilot secondary schools in Singapore in 1996. It provided a central repository of educational resources and lesson packages for teachers. STW was only introduced for the secondary one level with a fully ICT-based Science curriculum. The evaluation of the project indicated that it had succeeded in motivating students to learn Science. The project was then extended to Science at secondary two in the six pilot schools, with the STW being used for 30% of curriculum time for the subject.

The JCNet, on the other hand, was a Research and Development project on the use of the Internet and was implemented in two Junior Colleges in 1997. The ICT Masterplan that was launched in April 1997 had integrated and expanded the scope of these major pilot initiatives (AITP, STW, and JCNet projects). It took into account the lessons learnt from these initiatives. For example, several features of the STW had been incorporated in the Masterplan, such as the development of Digital Media Repositories (DMRs) of resources for use by teachers and the
involvement of private sector content providers in the project. In the course of implementing the 
ICT Masterplan in all secondary schools, further lessons were drawn from the STW project to 
decide on how such an initiative could be extended to other schools.

Lessons Learned and Recommendations

- The ICT Masterplan in education should be an integral part of the overall ICT Masterplan for 
  the country. In the case of Singapore, MP1 was part of the IT2000 initiative to transform 
  Singapore into an intelligent island where ICT permeates every aspect of the society.
- The MOE must work closely with other government organizations, especially the National 
  Computer Board.
- Pilot studies serve as good stepping stones to the successful implementation of the ICT 
  Masterplan. When formative and summative evaluations are carried out, best practices and 
  lessons learned from the pilot studies can be integrated into the Masterplan.
- Pilot studies should be carried out at different levels of education in the school system. In the 
  case of Singapore, there were three pilot studies that were targeted at Primary schools, 
  Secondary schools, and Junior Colleges. The context of operations, teaching and learning is 
  very different in the three levels.
- The ICT Masterplan in education should refine, integrate and expand the scope of the pilot 
  initiatives. If there is no follow-up action plan, the pilot studies will always remain as such 
  and not integrated into the Masterplan.

Issue 2: Transforming ICT for Education Policy into Action

Analysis of Strategies

The underlying philosophy of MP1 was that education should continually anticipate the future 
needs of society and work towards fulfilling those needs. The critical skills needed included 
“creative thinking, the ability to learn independently and continuously, and effective 
communication” (MOE, 1997). The following statements elaborate upon the previously outlined 
four goals of MP1:

1. *Enhance linkages between the school and the world around it, so as to expand and 
enrich the learning environment:* Teachers and students tap into a growing wealth of 
educational resources outside the school. They also communicate and collaborate 
with other educational institutions, local and foreign, and the community at large. 
These new learning connections help students develop the perspectives required to 
work and live in an increasingly borderless and complex world.

2. *Encourage creative thinking, lifelong learning and social responsibility:* Students 
develop competencies in accessing, analyzing and applying information, and develop 
habits of independent learning. ICT-based learning strategies also seek to develop 
students’ ability to think creatively, to cooperate with one another and to make sound 
value judgments.

3. *Generate innovative processes in education:* The integration of ICT in education 
itself engenders several broader innovations. ICT-based teaching and learning
approaches offer opportunities for designing new curricula and new methods of assessment to meet educational objectives. In addition, MP1 provides schools with autonomy to use ICT resources flexibly to meet the needs of their students. School designs also evolve to maximize the potential for using ICT to enhance learning and school administration.

4. *Promote administrative and management excellence in the education system:* ICT is used to promote greater and more efficient communication within the school, amongst schools and between the MOE and schools. It enhances the effectiveness of educational administration. Ready access to online data and information also supports effective decision-making at all levels.

MP1 was implemented in three phases: Phase I in 1997, Phase II in 1998, and Phase III in 1999. Schools that had a history of effective use of ICT in their curriculum were chosen to be the demonstration schools. These demonstration schools, known as Phase I schools, provided the rest of the schools in Singapore with concrete, local models of innovation in teaching and learning strategies, and in school administration using ICT. Altogether there were 22 Phase I schools, comprising of 10 primary schools, 10 secondary schools and 2 junior colleges/centralized institutes (JC/CIs).

Phase II and III schools started their ICT Masterplan implementation in 1998 and 1999 respectively. The identification of Phase II schools was based on the school principals’ own evaluation of their staff readiness to embrace the new initiative. There were 106 Phase II schools, while the remaining 268 schools were in Phase III. Schools within each phase were given the flexibility to decide on the pace of implementation.

In addition, the ICT CORE Training for all schools was completed by May 2001, where the teachers were trained in basic ICT competencies in the use of the word processor, spreadsheets and the Internet. Moreover, a four-tier fan model was put in place to acquaint teachers with ICT integration in every school. This started out with 60 senior ICT instructors from ETD who were trained before visiting schools to train, work with, and team-teach with teachers in Phase I schools. Together with some teachers and head of departments from Phase I schools, these instructors then went to Phase II schools. The details of the model are elaborated in Issue 1 of Component 7.

Besides the training, MOE provides other types of support, such as ICT competitions to motivate the schools. Some of the ICT competitions that have been organized so far are the National Software Competition, ThinkQuest – Singapore, Singapore ThinkQuest Junior, I-Micro Award, Learn@ and Schools Video Award. For example, the Singapore ThinkQuest Junior is an educational website design competition organized by MOE and co-hosted by MediaManager Pte Ltd. It encourages students aged 9 to 11 years to take a meaningful interest in computers and technology, and to take advantage of the Internet as a constantly growing source of information and as a powerful collaborative tool by designing and creating educational websites in teams of two to six members, guided by their teacher coaches ([http://thinkquestjr.moe.edu.sg](http://thinkquestjr.moe.edu.sg)). Opportunities have also been provided for schools to be involved in a collaborative effort with schools in other countries. Some of the international collaborations were with schools in Japan, United Kingdom and Chile.
Despite providing central support, MOE had clearly stated in its implementation procedure that the MPI was only a blueprint for the integration of ICT into education at the national level. Schools were given the flexibility to decide how they wanted to integrate ICT into their own school system to reach national standards. Therefore, Singapore schools were empowered to make decisions in choosing different strategies to implement ICT into their own school curriculum according to their needs and readiness, subject to MOE’s assessment of their readiness and needs. This decentralized policy of MOE created a variety of strategies that were adopted by the schools on how best they felt ICT should be integrated into their own school.

Lessons Learned and Recommendations

- The goals of the Masterplan should be consistent with the vision. It is the goals that drive the Masterplan to fulfill its vision.
- The goals should be formulated as actions that are observable and measurable. For example, “teachers and students communicate and collaborate with other educational institutions, local and foreign, and the community at large”. At different phases of the ICT Masterplan, these goals can be continually assessed to identify the gaps, and strategies may then be adopted to address these gaps.
- The phase approach of implementing the ICT Masterplan should be considered to keep the implementation process manageable, ensure a gradual build-up of best practices and lessons learned (rather than reinventing the wheel), and allow for formative and summative evaluations to revise and fine-tune the Masterplan.
- Demonstration schools may be considered in the ICT Masterplan to serve as models of ICT integration. Moreover, the staff from these schools can share their experiences and expertise with staff from other schools or the teachers from these schools can be posted to other schools to start their ICT integration process. Alternatively, the staff from other schools may be attached to these demonstration schools to observe best practices and immerse themselves in a culture that supports ICT integration.
- A decentralized approach of allowing schools to decide how they are going to adopt ICT to meet national standards should be considered. Different schools operate in a different sociocultural-historical context. Some schools may be less ready than others to integrate ICT into both administrative and instructional activities. This may be due to a strong resistance of the school culture towards change, or the basic ICT competencies of their staff. If these schools are given time to address the obstacles that they are facing before adopting ICT, the implementation of the ICT Masterplan in these schools is then more likely to be successful. Moreover, a decentralized approach allows schools to integrate ICT as they see fit to better meet their teaching, learning and administrative needs.
- Professional development is an important component of the ICT Masterplan. Teachers play a pivotal role in the ICT-based environment. To ensure that they are well-equipped with the skills, attitudes and knowledge of ICT integration, a comprehensive professional development program needs to be planned. This will be discussed in greater detail in Component 7.
- For professional development, teachers need support from the MOE. This may come in the form of the organization of competitions to keep students and teachers motivated and excited about ICT for teaching and learning, or coordinating international collaboration with other schools abroad.
**Issue 3: Legal and Regulatory Framework for the Use of ICT in Education**

**Analysis of Strategies**

The framework for the Internet by Media Development Authority (MDA) emphasizes public education, industry self-regulation, and minimum regulation through a transparent licensing framework. One of MDA’s main concerns is the ease of access to pornography on the Internet, especially by children and minors. Its regulatory focus is on mass impact websites that distribute pornography. The Internet Code of Practice seeks to identify what the community regards as offensive, namely, pornography, as well as violence and materials which may undermine Singapore's racial and religious harmony. It also spells out the obligations of Internet Service Providers (ISPs) and Content Providers (MDA, 2003). The three ISPs, Pacific Internet, SingNet and StabHub have launched their own Family Access Networks (FAN) that offer services to filter out most undesirable or pornographic sites. They are the Cyber Guard Family Access, Family Online and Infinity Family Access respectively.

Apart from filters provided by ISPs, there are commercially available software programs that help to block out unsuitable websites for young surfers. Software filters block certain web-based information at the users’ end. They are useful in blocking unsuitable contents from the curious eyes and minds of young surfers. And it is not just pornography that gets filtered out, but other forms of negative influences, such as websites that glorify drug abuse or hate sites. Two common filtering techniques are human analysis and software analysis. Human analysis is a labor-intensive way to determine if a website warrants filtering. Websites are reviewed one by one, and those with objectionable content are put in a "blocked list". Software analysis may be created with a database of block-worthy content, such as vulgar images or text. When somebody attempts to access a website, the software checks whether the site contains any block-worthy content, and performs a block accordingly. Although some schools in Singapore have been using such software, it is important to note that no filter offers a fool-proof way of avoiding every child-corrupting site that exists. For example, the human analysis approach will never be able to keep up with the dynamic, ever-changing nature of the Web. As for the software analysis method, it risks blocking out sites that are perfectly child-friendly. The official website of the White House, for example, was blocked in the past because it contained the word "couple".

While an initial filter is essential, online safety experts stress the greater importance of education. In a survey conducted by the NIE in 2001, it was found that teenagers generally favored educational strategies more than control measures. The items ‘discuss with child the dangers on the Internet’ and ‘learning more about the Internet’ (two educational strategies) were rated as most desirable by the teenagers, and the items ‘stop child from using the computer’ and ‘complain to Internet Service Provider’ (two control measures) were rated as the least desirable (Lim, Khoo, & Williams, In Press). Parents and teachers should talk to students about the dangers of being misled on the Net and should surf with them or guide them in their surfing. There are organizations that support parents, teachers and students in dealing with Internet issues such as pornography, misinformation, chat room dangers, and privacy. Two such organizations are the Parents’ Advisory Group for the Internet (PAGi) and TOUCH Community Services
(TCS). PAGi ([http://www.pagi.org.sg/](http://www.pagi.org.sg/)) is a volunteer organization set up as a support network for parents and guardians concerned about the online safety environment in which children surf. As a volunteer group, they depend on volunteers to assist them in various activities such as exhibitions, workshops, talks, and production of useful references such as handbooks and VCDs on online safety. These activities were usually carried out in the public libraries, community centres and schools.

TCS is a non-profit voluntary welfare organization and is a member of the National Council of Social Service. In 2001, TOUCH Youth Services launched Project CRuSH (Cyberspace Risks and where u Seek Help) - a public education effort commissioned by the Inter-Ministry Committee on Youth Crime (IMYC) to inculcate safe surfing values in youths. Project CRuSH ([http://www.planetcrush.org/maincover.aspx](http://www.planetcrush.org/maincover.aspx)) is committed to informing youth of the benefits, risks and dangers of the Internet, mentor youth to adopt positive values and safe behavior in the cyberworld, and develop youth to become positive influences on peers and juniors in cyberspace. It organizes road shows, Cyber Wellness Exposure program, parenting talk, online discussions and a peer-mentoring program. The Project CruSH team has been working closely with students and teachers in schools, and trainee teachers and lecturers in the National Institute of Education (NIE).

**Lessons Learned and Recommendations**

1. Initial filtering of the Internet from undesirable websites is necessary. This is particularly crucial among the younger students who may not be able to discern the validity and reliability of the information. Although such filtering may be an excellent idea, it is not foolproof and Internet-savvy children can still get around it. Some extreme measures adopted by some schools may be to keep their students off the Internet entirely, unless supervised by teachers. However, such measures deprive the student of the essential tools for survival in the 21st century.

2. Education of Internet safety issues both at home and in school should be an integral part of parenting, as well as teaching and learning activities. Education about the dangers of the Internet offers better protection than any software or hardware devices (Aftab, 2000). Therefore, rather than worrying unnecessarily, schools and parents should guide students surfing the Internet, and discuss Internet issues with them (Turow & Nir, 2000). Schools should also allow children to share their experiences online and give them opportunities to teach the teachers and parents what they know.

3. Teachers and parents need to be trained and supported to educate their students and children about online safety.

4. The training and support should come from government organizations, voluntary organizations or schools.

**Issue 4: Macroeconomic Impact of ICT in Education: Narrowing the Digital Divide**

**Analysis of Strategies**
The Internet dial-up penetration rate is about 47.2% in April 2002; that is about two million subscribers. Based on a survey of broadband usage in 2001, there were about 950,000 users in Singapore; that is about 34% of Singapore’s population (MICA, 2003). These statistics may look impressive, but Singapore, like most countries, is confronted with the issue of digital divide. According to the Annual Survey on Infocomm Usage of Households and by Individuals for 2001, the personal computer ownership and Internet penetration were higher in private housing units than in public housing units. The percentages for PC ownership and Internet penetration were 81.2% and 73.9% for private housing units as compared to 59.6% and 52.4% for public housing ones (IDA, 2002).

However, compared to the 1996 figures, the digital divide may have narrowed substantially. In 1996, the PC ownership and Internet penetration were 64.8% and 23.1% for private housing units as compared to 31% and 6.1% for public housing ones. The Singapore government has been committed to bridging the gap. It committed S$25 million to promote PC and Internet awareness and use in the people sector through collaboration with community groups and voluntary welfare organizations. Moreover, a key initiative was launched in 1999 to benefit 30,000 low-income households with a monthly income of not more than S$2000. These households were provided with used PCs bundled with free Internet access and basic training (Choi & Toh, 2000). While six hardware and software providers, and one ISP funded this effort, MOE was the largest donor of the used computers. For more details of donated computers, please refer to Component 5, Issue 5.

The ICT Masterplan in Education supported these efforts to narrow the digital divide by increasing the use of ICT across the curriculum in schools, the lowering of student-computer ratio, the enhanced accessibility of students to computers due to more open access areas, and the cheaper access to the Internet for students due to school-industry partnership. Although the more economically better off students would probably have greater access to the computers and Internet out-of-school, the ICT Masterplan ensured that all students, regardless of socioeconomic background, would have equal access to these ICT facilities in school.

Lessons Learned and Recommendations
- The ICT Masterplan in Education has macroeconomic implications such as the narrowing of the digital divide. With investment of ICT facilities in schools, the accessibility to computers and the Internet will increase for the students from lower socioeconomic background. With equal access in schools, the digital gap between the have’s and have not’s will be narrowed.
- The ICT Masterplan in Education should complement other government initiatives to narrow the digital divide. These may include public education of ICT, donated computers and free Internet access.

Issue 5: Inter-Ministerial Collaboration: MOE-IDA Collaboration

Analysis of Strategies
The MOE collaborated with various government organizations in the planning and implementation of the ICT Masterplan in Education. These collaborations are described in other sections of the case study. The focus of this section is on the collaboration projects between IDA and MOE, namely the FastTrack@School project (http://schools.s-one.net.sg/index.html), that was launched in September 1999. It aimed to make Singapore ONE (S-ONE) relevant and useful to schools so that teachers and students would use S-ONE for teaching and learning activities. Singapore ONE is the world’s first national broadband network. Over 300 interactive, multimedia applications and services have been developed in Singapore for delivery to offices, homes and schools.

The Fast Track@School encompassed 3 initiatives:
- Create relevant and useful broadband content for schools on S-ONE.
- Help schools to get pervasive S-ONE access in schools; and
- Help students to get S-ONE access from home at an affordable rate.

These initiatives were open for applications from all schools. Interested schools were invited to submit an Initial Project Proposal to outline their project plans. Proposals from schools and industry members were assessed together by MOE/ETD and IDA. 27 schools were selected to take part in the pilot for the year 2000.

In order to encourage industry-school partnership, IDA also initiated the Adopt-a-School Project that would be driven by industry partners. These partners helped schools to develop and provide a wide range of innovative services suitable for schools using Interactive Broadband Multimedia (IBBMM) technologies. These partners also assisted the school to create and acquire the necessary content on Singapore ONE, developed tools and platforms for teachers and students, provided training for teachers and students to familiarize them with the tools and the content, and provided technical assistance to maintain and update the content for the teachers and students. In many instances, the partners explored with teams of teachers and students to improve upon the pedagogical aspects of IBBMM in the school curriculum.

Some examples from the Adopt-a-School Project include the Physics experiments at St. Andrew’s Junior College, and the Falling in Love with Raffles Museum of Biodiversity Research (RMBR) at Crescent Girls’ School. The project in St. Andrew’s Junior College (http://onezine.s-one.net.sg/@School/Standrew/) consisted of a set of 30 Physics experiments with video illustration and online technical notes. The experiments illustrated and explained basic physics principles, reinforced basic concepts, and allowed for reflection of concepts and principles learnt. The Falling in love with RMBR (http://onezine.s-one.net.sg/@School/RMBR/index.html) was about how the students in Crescent Girls’ School got to know RMBR and the exciting things they have found there.

In another initiative, IDA and the National Council of Social Service (NCSS) collaborated with eight companies to help students in special education (SPED) schools to harness ICT in their learning. Using the computers, the students in these schools collected data, analyzed them and drew graphs and charts, and gave presentations. This joint initiative launched in 2000 was called SPED.com (dot-comming our Special Education Schools). By August 2000, it had raised about S$1.8 million to provide SPED schools with ICT infrastructure and set up a trust fund for...
students with special needs. The trust fund was for the needy, disabled students to purchase PCs and assistive equipment for educational purposes (IDA, 2000).

Lessons Learned and Recommendations

- The MOE should tap into the expertise and experiences of other ministries and government agencies. In the case of Singapore, the MOE worked very closely with the IDA on various projects. These projects drew upon the technical and connectivity expertise and experiences of IDA, as well as tapped into IDA’s database of industry partners.
- The MOE should also tap into existing infrastructure to avoid duplication of products or services. In Singapore, MOE worked with IDA to tap into the Singapore ONE national broadband network with interactive, multimedia applications and services.
- When developing ICT-based resources, industry partners and government agencies should work closely with schools, especially teachers and students. This will ensure that the design and development of the ICT-based resources are pedagogically sound and meet the teaching and learning needs of the teachers and students.
- When working with another ministry or government agency, the MOE needs to make explicit and clear its vision of the ICT Masterplan. This vision can then be translated into action plans to be carried out collaboratively. The MOE-IDA collaboration on the FastTrack@School project is a very good example.
- Inter-ministerial collaborations need not be confined to ministries and government agencies; they should plan for and encourage the participation of the private sector that has its own expertise and experiences.

Issue 6: Obtaining Support of Policy Makers and Other Stakeholders of the Various Departments of the MOE

Analysis of Strategies

As Singapore moves into the new millennium, the spectacular proliferation and integration of computers and networks have fuelled the creation of a global information environment. In the face of this continuing and rapid technological change, the job market requires people who are adaptable to change, and who can discard obsolete assumptions without trauma. To survive in the marketplace, schools need to enculturate their students to be lifelong learners – to learn how to seek out new information, think critically and show initiative to meet the challenges of the fast-changing world. The primary motivation for integrating ICT in education is its potential in mediating this enculturation process. As MP1 is consistent with the country’s quest to build up its KBE to ensure her sustainability, the Masterplan is able to gain the full support of the policymakers and other stakeholders of the MOE.

In the launch of MP1, the Minister of Education (MOE, 1997) emphasized that Singaporeans must “think beyond the obvious, to think creatively, to search for new knowledge, to come up with new ideas. They must be comfortable with new technologies and be able to exploit these new technologies to venture beyond their current boundaries and open up new frontiers of
knowledge.” In the history of mankind, technology has always been an agent of change. Major technological innovations, such as photography, electric light, locomotive and movies, have resulted in entire paradigm shifts. They have made sweeping changes in the way people work and play. For ICT, it has already changed the way people communicate and do business, and more recently, it is poised to bring about a paradigm shift in the way people learn. Such changes are taking place in the way educational materials are designed, developed, and delivered to those who wish to learn. These changes were identified and highlighted to policymakers and other stakeholders of the various departments in MOE.

The policymakers and stakeholders were also made aware of the various ICT in Education blueprints of other countries. These blueprints were brought up by the Minister’s speech (MOE, 1997) during the launch:

“The United States has established a $200 million Technology Literacy Challenge Fund which will give American students access to computers. Over 6000 schools will be linked.”

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

“Finland, with a population of just 5 million, has launched a 5-year plan, for a national strategy in "Education, Training and Research in the Information Society". Finland is already the country with the highest connections to the Internet in the world.”

Lessons Learned and Recommendations

- In order to gain the support of policymakers and other stakeholders of MOE, the ICT Masterplan in Education should link its objectives to national objectives, such as building the human capacity of the citizens within the country. This can then be linked to economic growth and sustainability.
- Policymakers and stakeholders need to be made aware of the existing ICT Masterplans in education of other countries, as well as the benefits of ICT in education. When these real-world examples are identified, documented and presented, policymakers and stakeholders are more likely to support the ICT Masterplan in Education.
- Policymakers and stakeholders should also be convinced of the urgency of the implementation of the ICT masterplan. The pentium speed of technological changes and paradigm shifts in society should be highlighted and explained.
Component 3: Management and Financing (national AND school levels)

Issue 1: Resources at Ministry Level and at School Level That Make ICT Programme Work

Analysis of Strategies
With a budget of S$2 billion, MP1 was implemented to network all schools, equip them with at least 1 computer to every 5 students, and train all teachers in ICT integration. The networking allowed courseware, the Internet and digitized media resources to be accessed in every classroom and in all learning areas in the school. It also allowed for sharing of teaching resources within and between schools in Singapore. The details of the resource allocation and technological infrastructure have been given under Issue 2 of Component 2 and all issues of Component 5. Although schools were provided with the basic technological infrastructure, they have the autonomy in deciding on the ICT resources and tools that they should acquire based on their own visions and analyses of their students’ learning needs.

At the same time, S$4.5 billion of the MOE budget was allocated for the Program for Rebuilding and Improving Existing Schools (PRIME) where schools would undergo redevelopment and be equipped with the most updated facilities. These facilities included computer laboratories, media resource libraries, ICT learning resource rooms, bigger classrooms, pastoral care rooms and health and fitness rooms. The upgrading involved the construction of extension blocks and alteration of existing school buildings, and the rebuilding involved the construction of new buildings. The construction were carried out in phases; where the phasing of schools was determined by the age of the school, the state of existing facilities in the school, and the availability and suitability of school site. All these investments have offered schools with new possibilities to take up the opportunities of ICT to enhance the educational processes.

Lessons Learned and Recommendations
- At the national level, there must be an initial financial investment by the government to equip schools with the basic technological infrastructure and ICT resources.
- The investment in the technological infrastructure and resources must be complemented with an investment in the physical learning environment of schools. The latter provides a conducive environment for the former investment to be effective. For example, bigger classrooms allow a few computers to be allocated in them and provide teachers with more possibilities of ICT-based learning activities.
- Every school is different and hence, they should be given some autonomy to determine which ICT resources are most suitable for the teaching needs of their teachers and learning needs of their students. This will ensure a better fit of ICT in the school curriculum and hence, a better degree of ICT integration in schools.
The ICT Masterplan in Singapore has been able to mobilize financial and resource support from both statutory boards and private organizations. One statutory board was the Infocomm Development Authority of Singapore (IDA) that initiated the FastTrack@School Program. As stated earlier, the program was aimed at encouraging industry partners to jointly develop useful and relevant broadband education content with schools for teaching and the curriculum. A total of S$7.5 million was allocated under the pilot for broadband access at schools and homes, as well as content on Singapore ONE and Adopt-A-School initiatives. These initiatives have been explained in great details under Issue 5 of Component 2.

The MOE signed memoranda of understanding (MOUs) with many industry partners under the School-Industry Partnership Scheme (SCHIPS). The scheme was initiated under MP1 in 1997. The SCHIPS was set up to involve ICT companies to jointly explore with schools the use and development of ICT that would enhance teaching and learning. In the long term, SCHIPS aimed to promote the development of the educational technology industry in Singapore. The first two MOUs were signed with Singapore Technologies Computers Systems and Services Pte Ltd (STCS) and Educom Pte Ltd (Educom) in 1998. STCS worked with two schools to provide technology solutions, such as customizing a learning resource management system called School Enterprise System, developing educational courseware and tools, providing training and support to help the two schools to integrate its technology solutions into the curriculum. In the case of EduCom, they worked with four primary schools on an integrated learning management system called SuccessMaker that was developed by a US-based educational software developer, Computer Curriculum Corporation. Educom also provided innovative computer furniture for the classrooms, and training and support for the teachers. These two projects were co-funded by MOE, IDA (the then National Computer Board) and the respective industry partners. They cost about S$3.67 million, with the two industry partners contributing a little less than a third.

MOUs were also signed with MNCs such as IBM and Apple. Under IBM’s Reinventing Grant for Singapore, IBM International provided services, technical resources, training and research with a market value of US$425,000 that included the assignment of a project manager, IBL resources and independent, third party evaluation of the partnership. MOE provided the necessary hardware and infrastructure for the implementation and matched IBM’s resources, dollar-for-dollar in terms of teacher time for training, shared best practices and showcased key elements of the partnership. The S$1.4 million Singapore-Apple Collaboration Project (SAC) is the first project to be implemented in July 1999 under the umbrella of edu.QUEST, which stands for Quality and Excellence in Schools through Technology. The main objectives were to explore innovative approaches to staff development, wireless mobile computing and media-rich tools, and also to create vibrant learning communities where exploration and experimentation were integral to the learning process. Teachers and students were then innovators and experimenters rather than knowledge-dispensers and receivers.
The SCHIPS was able to mobilize financial and resource support for the implementation of the ICT Masterplan in Education. More important, by working with industry partners, MOE has explored new technologies with schools, created new ICT-based learning resources, examined state-of-the-art learning environments, and provided pedagogy-based training for teachers. MOE also collaborated with public bodies (e.g. museums and the zoo) to create authentic and varied learning projects for the students.

Lessons Learned and Recommendations

- School-industry partnerships should be an integral part of all ICT masterplans in education. They not only mobilize financial and resource support for the implementation of the Masterplan, but also allow schools to explore and experience emerging technologies and pedagogies.
- Industry partnerships should involve the private sector, statutory boards and government bodies. Each type of partnership provides schools with different perspectives and opportunities of how ICT can be integrated into the school curriculum to enhance the learning experiences of their students.
- The signing of an MOU is an important first step towards school-industry partnership. The support given by individual industries may be financial or in kind.
- The MOE should commit itself financially, and in terms of resources, to the partnership projects. With such a level of commitment from MOE, industries are then more likely to agree on the partnership.

Component 4: ICT in Schools – Policy, Visions and Strategies

Issue 1: Creating School ICT Vision/Plans

Analysis of Strategies

Many researchers have pointed to the school ICT vision as essential to the effective integration of ICT in schools (Kerr, 1996; Murphy & Gunter, 1997; Anderson & Dexter, 2000). Ertmer (1999) wrote, “A vision gives us a place to start, a goal to reach for, as well as a guidepost along the way” (p. 54). Means and Olson (1997) thus recommend that teachers and schools develop a vision before they make substantial investments in hardware and software. In the interviews conducted by IDA (http://schools.s-one.net.sg/findings1.html) with teachers, head of departments and principals in Singapore schools, respondents offered various perspectives of their respective schools' vision on the deployment and use of ICT in education.
Respondents interviewed were aware of the importance of schools’ vision in the effective integration of ICT. Some of them had set their schools’ ICT vision towards benchmarking the top academic and elite schools in Singapore, which had been on the forefront of the ICT integration. For others, the effective deployment of ICT in areas of teaching and learning to raise the performances of their students is the vision. In Crescent Girls’ School, the vision is deploying ICT in reaching out to the community at large. The school leadership firmly believed that ICT must not be deployed in isolation, but rather, it needed to serve the community. The provision of a pervasive ICT environment to improve the quality of life of the teaching staff and the students was the vision at Victoria Junior College. Both infrastructural and innovative interactive multimedia courseware content were planned to meet the objectives that were driven by the vision. For Rosyth Primary School, the vision was to embrace ICT to achieve administrative and academic excellence. As ICT permeates the entire spectrum of society, the school is committed to help its students appreciate the relevance and the appropriate application of ICT. These visions of ICT in education of the various schools are consistent with that of MP1 and MP2 where ICT is deemed as an enabler to enhance the teaching, learning and administrative processes in schools.

After a vision has been successfully created and accepted, the next step is to articulate an ICT integration plan, which spells out clearly how teachers will be expected to integrate technology in their lessons (Strudler & Wetzel, 1999). An ICT integration plan provides a detail blueprint of the steps and methods needed to translate the school ICT vision into reality. Most schools in Singapore have ICT integration masterplans that have been customized for their own school culture and environment. These masterplans addressed the following questions:

- What are the priorities for implementation of the ICT masterplan (e.g. staff, students, content areas)?
- What evaluation standards and benchmarks indicate effective integration of ICT?
- Who is ultimately responsible for successful implementation (e.g., ICT committees, administrative personnel, teachers, technical support staff)?
- What funds and time are available to implement ICT integration efforts?

Developing ICT integration plans is no doubt a complex and time-consuming affair, but they are usually well worth the time and trouble they may take to put together (Hoffman, 1996).

**Lessons Learned and Recommendations**

- A school must have a clear vision of its ICT integration strategies, and this vision must be shared by all members of the school community. That is, teachers need to know exactly how ICT is to be used as a tool in the teaching and learning context.
- Although it usually requires a school leader to champion it, the vision itself should not be created by a single person. It is crucial to pull together those who have a stake in the outcome, including teachers, parents, students, and the community, and allowing them to assist in the creation of the vision by contributing their knowledge, skills, and positive attitudes helps build a strong acceptance, commitment, and potential for lasting change. An ICT vision that is accepted by all becomes a shared vision, which is critical to the successful implementation of ICT in a school setting (Costello, 1997).
Once the vision has been created, the school needs to design and develop a ICT masterplan of its own. This is to operationalize the vision that has been jointly created by all stakeholders of the school community.

The ICT masterplan of the school should be customized according to the vision of the school and its sociocultural settings. It should consider issues of staff and student development in ICT-related skills, curriculum and assessment, ICT facilities and resources, and support team (both technical, administrative and pedagogical).

**Issue 2: Supporting School Policies that Facilitate Uptake of ICT in Schools (School Leadership)**

**Analysis of Strategies**

School leaders can lead the way by improving their own ICT competencies through the attendance of staff development with classroom teachers, using ICT in their daily administration and communication tasks, and allowing teachers time to experiment with new teaching methods using ICT. In Singapore, there are many examples of how school leaders have facilitated the uptake of ICT in schools. Many school leaders scaffold the process of ICT integration in their schools by:

- Sending out all school announcements via e-mails to all the staff;
- Requiring all teachers to submit their weekly lesson plans via e-mails to their HODs;
- Uploading all forms (such as, transport claim, leave application, training development application, and medical claim) onto the school intranet for teachers to download;
- Encouraging staff to communicate and share via e-mail and other asynchronous and synchronous ICT tools; and
- Requiring teachers to submit their class daily attendance via the online portal.

These scaffoldings ensured that ICT gradually become part of the school culture and helped some “technophobic” teachers to overcome their initial fear of using ICT. As teachers began to use ICT to carry out their daily non-teaching tasks, they open themselves up to the teaching and learning opportunities provided by ICT. They would then begin to explore how ICT could be integrated in their lessons to enhance the teaching and learning process. Although MOE has recommended that 30% of the curriculum time should involve the use of ICT, most school leaders perceived that as a guideline rather than a rule or regulation. An increasing number of school leaders have realized over the last three years that ICT should not be integrated into the curriculum for ICT sake. Instead, they believed that teachers should explore ways of integrating ICT into the curriculum to enhance the learning experiences of their students. These leaders adopted strategies such as:

- Planning contact time for teachers to share their experiences of using ICT in their lessons;
- Initiating industry-teacher partnerships to deliver just-in-time ICT training for students and develop instructional ICT-based materials for teaching and learning;
• Peer-teaching of ICT-related skills based on the apprenticeship model or just-in-time learning;
• Collaboration with other schools to share expertise and experiences on ICT integration;
• Equipping each teacher with a personal laptop so that they would explore the opportunities of ICT and make that part of their lives;
• Employing more technology assistants to support the teachers in ICT use; and
• Purchasing more laptops so that teachers would not be constrained by the availability of the ICT facilities (such as computer laboratories and media resource rooms).

In order to provide teachers with the administrative and pedagogical support, schools in Singapore have created the position of ICT coordinator or HOD (ICT). The ICT coordinator or HOD (ICT) is a staff specialist whose main role is to help teachers to coordinate ICT planning and development. He/She provides administrative support by supervising computer facilities, ordering supplies, and maintaining hardware and software, liaising with hardware and software vendors, and service personnel, and collaborating with teachers and school leaders in preparing hardware/software budgets, reports, and proposals. The coordinator or HOD also provides pedagogical support by assisting teachers in evaluating and selecting hardware and software, and conducting needs assessments to determine what additional hardware or software that might be desirable for the teachers and students’ needs.

All these strategies adopted by the school leaders encouraged the uptake of ICT in schools, and provided a conducive environment for the effective integration of ICT in the curriculum.

Lessons Learned and Recommendations

• School policies must encourage and support the uptake of ICT by teachers. The school leaders may initially adopt strategies that make ICT part of the daily routine or tasks of the teachers. These strategies may include using e-mail as the mode of communication among staff, accessing the Intranet to download forms and using a word-processor to complete lesson plans for submission. The school leader should be the role model in this case to make ICT a tool in his/her everyday life.

• Guidelines for ICT use in the curriculum that have been set by the MOE should not be imposed as a regulation or rule to be strictly adhered by. This may stifle creativity and may lead to a technologically driven approach towards ICT integration. The school leaders should be given the autonomy to decide on how to implement the guidelines based on their analyses of their schools’ readiness.

• School leaders may also employ strategies to provide their teachers with the platform and support to integrate ICT into their school curriculum. These strategies may include sharing sessions of ICT use among teachers, peer-teaching and team-teaching based on an apprenticeship model, and employment of more technology assistants to support teachers.

• The appointment of an ICT coordinator or HOD (ICT) provides the administrative and pedagogical support for the teachers. It is crucial that this appointment is not confused with that of a technology assistant. The role of the ICT coordinator or HOD(ICT) should include advising teachers on ICT solutions to their teaching or learning problems, helping teachers acquire ICT resources, and conducting training needs assessment of teachers’ ICT-related capacities and advising them of their professional development.
Issue 3: Parents and Community Involvement

Analysis of Strategies
A wide range of activities that involved parents and community were observed in Singapore schools. This may be due to the school-industry partnership in place and the autonomy given to schools in the ICT Masterplans. Moreover, with better connectivity linking the school to the home and the community, peers, teachers, parents and other members of the community could play a more active role in the students’ learning experiences. One example was the “Learning Village” project in Outram Secondary School under the MOE-IBM Collaboration. The Learning Village is a School-Community Web Collaboration System using the Internet to foster home-school-community connection and partnership. Parents, teachers and students in the school have collaborated in project work, shared information and discussed teaching, learning and parenting issues. By connecting the various stakeholders of education, the Learning Village has mediated the school’s effort towards the mission of “An Intelligent School and a Caring Family”.

Parents, industry experts and academics were also invited to work with schools to make meaningful contributions to the community (Soh, 2002). One good example is the service learning program in Crescent Girls’ School (www.crescent.edu.sg) where students use ICT in an innovative way to make a difference to the lives of less fortunate members of the community. In 2000, a group of Secondary three students set up an e-commerce project, “Very Special Bazaar”, together with members of Peacehaven (Home for the Elderly), Movement for the Intellectually Disabled of Singapore (MINDS) and The Very Special Arts Singapore. Art and craft pieces were put on sale via the website with an e-commerce engine, and the proceeds went to the elderly and the physically and intellectually challenged in these organizations. Another two projects by the school involved the Singapore School for the Deaf (SSD) where the hearing-impaired students and Crescent’s students co-designed digital art cards to raise funds. They also wrote, illustrated and translated into sign languages readers for the lower primary students in SSD to enrich the teaching and learning resources for the hearing impaired community. Other projects in the school included e-tutoring services for children from the Jaiyah Children’s Home and creating an animated version of a story using clay figurines with SDD.

In Radin Mas Primary School (http://www.moe.edu.sg/schools/radinmas/), there were also many community projects that were mediated by ICT. In 2001, the Primary five students commenced a project entitled, “Shangrila for the Seniors”. The main objectives of the project were to encourage students to care for the elderly and engage students in an entrepreneurial pursuit to help the elderly. The students communicated with directors of senior citizen centres overseas and locally, interviewed grandparents, and teachers who would be retiring. Based on the information collected, the students then designed a Senior Citizen Centre for the elderly with the help of three-dimensional software. They also suggested program and special menu/diet for the retirement village. These were eventually posted on interactive webpages. In other projects, the students designed mousepads, jigsaw puzzles and mugs to sell at shopping malls in support of the National Kidney Foundation – Children’s Medical Fund. To involve the parents in school
activities, Radin Mas also set up a Parent Link website. The mission of the Parent Link was to promote rapport among parents and with the school, and foster mutual support to shape the overall character of their children through their involvement in the school program.

ICT has afforded Singapore schools with better linkages between schools, home and communities that provided teachers, peers, parents and members of the community to play a greater role to enhance the students’ learning experiences. These experiences included engaging in authentic problem solving, working with researchers and honing their entrepreneurial skills. The bonds between schools, home and the community were also strengthened through increased interaction and communication.

Lessons Learned and Recommendations

• ICT opens up opportunities for the schools to collaborate with different organizations and people in both the local and international communities. Schools should establish linkages with a variety of communities to develop the overall character of the students. The projects in Crescent Girls’ and Radin Mas Primary School are good examples of how students learn to care and relate to the less fortunate members of the community, and at the same time, develop their entrepreneurial dispositions.

• ICT may mediate and strengthen the home-school connection, and hence, should be properly harnessed to promote parent activities and involvement in the school.

• With the appropriate support and autonomy, schools are capable of innovative ICT-based projects to improve bonds between schools, home and community.

Component 5: Technology Infrastructure and Connectivity

Issue 1: Broadband Connectivity from Students’ Home

Analysis of Strategies

Although all schools in Singapore are already on the broadband network, the take up rate of broadband subscription by students for their home is quite varied; high for some schools (more than 75%) and low for others. In the interviews conducted with school principals and teachers by IDA in 2002 (http://schools.s-one.net.sg/findings2.html), it was highlighted that students in some schools were already subscribing to broadband access without the subsidies offered under FastTrack@School. However, the students of some other schools complained that the subsidy of S$10 was meager and experienced difficulties trying to convince their parents to subscribe for
broadband services. The take up rate was also quite low for junior college students as they were at the college most of the time and were able to access the broadband multimedia content from the multimedia labs in their colleges.

Some respondents felt that the low take up rates in their schools might be due to insufficient promotion on the part of the schools of the broadband subscription plans. Although they welcomed the various ISPs’ marketing efforts to promote broadband subscription, they admitted that they had different priorities with competing initiatives being implemented at the same time. Most of the respondents raised their concerns that with the wrapping up of the FastTrack@Schools project, there might be a fall in broadband subscription among students as the subsidies would be withdrawn. Until 2002, the $10 off the broadband access standard packages for student home access is part of the S$150 million package announced in April 2000 under the Infocomm21 to jumpstart the development and growth of the Interactive Broadband Multimedia industry.

All of the respondents have cited continuous subsidized rate for broadband subscription at the top of their ‘wish-list’. Many respondents cautioned that prices must be kept affordable and competitive for the students especially for those from the lower income families. However, they stated that they would continue to support the marketing and promotional efforts of the ISPs to boost the level of broadband subscription. While continuous subsidies were crucial, some respondents deemed that the broadband content must be beefed up to sustain the interests of the subscribers. They urged that IDA should continue its collaboration with MOE to ensure that relevant and useful broadband interactive multimedia content was emphasized and highlighted in its design and development.

**Lessons Learned and Recommendations**

- Home broadband connectivity is ideal to encourage the design and development of broadband multimedia resources by teachers, and engage students in tasks that are facilitated by broadband multimedia resources.
- However, to avoid the digital divide among students from different socioeconomic background, the broadband subscription plan for home access should be subsidized or made more affordable. Alternatively, schools can provide more open access areas where students can access the interactive multimedia content.
- Schools may want to work closely with ISPs to promote broadband connection from home. However, this will depend on the proportion of online learning activities that the school has designed and organized for the students.
- One must be wary of subsidizing broadband accessibility from home. In reality, broadband connections may be used for entertainment purposes rather than educational ones.
- Although home broadband access for the students is ideal, what is more important is to ensure the quality and relevance of the interactive multimedia content. This content is necessary to facilitate the learning and teaching processes in schools.

**Issue 2: Online Learning Market in Singapore**
Analysis of Strategies

The online content market started to take off around 1999-2001 after the launch of MP1 where schools were equipped with the basic technological infrastructure. However, after the launch of the FastTrack@School program, more schools have been actively planning and organizing learning and teaching activities to take up the opportunities of broadband connectivity. Between November 1999 and June 2002, IDA spent $9.8 million to fund 42 schools in its FastTrack@School program, with the aim of encouraging the use of broadband for teaching and learning. According to an IDA survey done in March 2002, there were 120 schools using online content. By now, the figure is estimated at well over 200.

The recent Severe Acute Respiratory Syndrome (SARS) outbreak that led to school closure in Singapore had enabled online learning to show its worth to teachers, parents and students (Choudhury, 2003). Inevitably, this gave an unexpected boost to the online learning industry. Schools have shown greater interest in continuing their online teaching and learning program developed by these companies. The managing director of one of the biggest online companies in Singapore commented that “the SARS outbreak has made people sit up and pay attention, and may result in the 'legitimizing' of e-learning and turn it into a 'mainstream necessity' with impact reaching beyond the school closure”. He estimated the current size of the Singapore school online learning market to be about S$40million but expected the figure to increase to between S$50 and S$100 million by 2005.

Due to Singapore’s well-developed broadband infrastructure and its reputable education system, she provided a good test-bed for many online learning companies operating in the country. More than half of the students entering primary schools have already some online learning experiences, and this trend will continue to spread upwards through primary schools to secondary schools to adult life-long learning. By using Singapore as a test-bed, these companies develop online learning products for schools that may be customized and marketed to the larger regional market. Based on a Frost and Sullivan survey, the school component of the online learning market in Asia is about US$479.58 million in 2003, and is expected to go up to US$1,211.98 million by 2005. This represents a compound annual growth rate (CAGR) of 64.46 per cent through 2005. IDA estimates that by 2005, the Singapore academic market will be in the region of US$27.8 million. But if Singapore companies secure just 5 per cent of the regional academic market, this figure could swell to US$88.4 million. However, unlike Singapore, many of the countries in the region are still lacking on the infrastructure (such as PCs in schools, Internet or broadband access) to cope with the online multimedia content (Choudhury, 2003).

Lessons Learned and Recommendations

• The integration of broadband multimedia content must be supported by the necessary ICT infrastructure in schools. This will encourage the widespread use of multimedia teaching and learning materials. In Singapore, the use of broadband multimedia content by schools was supported by MP1 and the FastTrack@School program. And all these were situated in a reputable education system that has provided young children with learning experiences online.
• In order to encourage the setting up of online learning companies, there is a need to put in a place a structure. The structure includes funding and collaboration with schools and MOE.
• Rather than developing their own content and online learning platforms, schools in countries may draw upon regional companies that are experiences, materials, technologies and expertise, and localized the content and online learning platform for their own country.
• Broadband interactive multimedia in schools should be further explored to optimize its potential for teaching and learning. In the case of Singapore, the SARS crisis made some schools re-examine their approaches to online learning.

Issue 3: Donated Computers

Analysis of Strategies
Under the ICT Masterplan in Education, no new computers were donated; instead, under the PC Re-Use Scheme that was initiated in November 1999, MOE planned to donate an estimated 10,000 used PCs to needy families over a five-year period. The scheme, managed by IDA, aimed to improve underprivileged Singaporeans' access to ICT by providing them with refurbished PCs. To be eligible for the scheme, the person must be a Singapore Citizen or Permanent Resident from a household with gross income not exceeding $2000 per month. The person or a member from the household must have attended the National IT Literacy Program. Once approved, the applicants only need to pay a nominal administrative charge for the refurbished PCs.

The first batch of PCs went to needy families identified by Singapore Indian Development Association (SINDA), Council for the Development of Singapore Muslim Community (MENDAKI) and the Northeast Community Development Council in March 2000. MOE has been one of the largest donors of computers to the scheme as it replaces the PCs in schools every three to five years as part of the Masterplan for ICT in Education. In fact, up to 12,000 PCs in schools are replaced annually from 2002 to ensure that computers used in schools keep pace with technological developments. Figure 1 shows how the old computers in Singapore schools are disposed of.
Lessons Learned and Recommendations

- Old computers in schools that have exceeded their lifespan may be redeployed in the schools for other uses or may be offered to needy students in the schools or other government and charity organizations.

- The redeployment of old computers to needy students and households should be a collaboration between schools, MOE, and other government agencies/organizations or self-help groups. In the case of Singapore, IDA is the coordinator of the PC Re-Use Scheme as it has the technical expertise and connections to industry partners. The old computers from schools are refurbished and tested before they are distributed to successful applicants of the scheme.

- Old computers that have exceeded their lifespan will involve maintenance and support costs for the users. These costs must be taken into account in the cost-benefit analysis to help users make an informed choice between new and used computers.

Component 6: Curriculum, Pedagogy and Content Development

Issue 1: *Integrating Technology into the Curriculum and Assessment*
**Analysis of Strategies**
Under MP1, ICT was integrated into all subject areas, as software and other ICT resources consistent with curricula objectives became available. The initial focus at the primary level was on English, Mathematics, Science and Chinese Language. At the secondary level, the focus was wider that included subjects like Geography, History, English Literature and Civics and Moral Education. There was extensive use of the Internet in many of these areas in the secondary level. Open tools such as word-processing, spreadsheet, and presentation packages were also used for all subjects, including mother tongue languages.

In these lessons, ICT was employed to facilitate the shift of learning from information receiving towards finding, collating and synthesizing relevant information, and from learning to apply information to solving problems and communicating ideas effectively. The use of ICT also strengthened the teacher’s repertoire of skills and open up a wider array of learning resources for students to access. This provided a greater degree of independent learning, encouraging more able students to expand their horizons beyond the standard curriculum. The rich, interactive capability of ICT-based learning resources also motivated and engaged weaker students, and allowed them to learn at an appropriate pace. To support the learner autonomy of the students, teachers provided them with worksheets and checklists, and engaged them in dialogues to scaffold the learning processes.

Students were also expected to acquire specific ICT skills at each stage, from primary school upward. By the time they leave secondary school, most of them had acquired minimum competencies in desktop publishing, spreadsheet and database construction, and in sourcing of information from CD-ROMs and on-line resources. In the survey conducted by IDA in 2002 (http://schools.s-one.net.sg/findings1.html) about the readiness and preparedness of the staff and students for the FastTrack@School, all the respondents (teachers, principals and HODs) agreed unanimously that the students who grew up in the ICT era were ready and prepared for the FastTrack@School (broadband technologies and learning resources) initiative. They welcomed the deployment and integration of technology in their curriculum.

Some of the respondents shared their experiences of ICT integration in their schools. The teachers at River Valley High School began their training of integrating ICT into teaching and learning with the implementation of the ICT Masterplan in Education. They explored as a school the use of ICT as a learning tool and rigorous training program were offered by private vendors and their own teachers to ensure that all teachers could conduct ICT-based lessons. These enabled them to jumpstart the use of ICT at a much faster pace than their contemporaries. Moreover, with encouragement and assurance, the teaching staff were able to accept ICT and integrate it effectively into the curriculum. The implementation of the ICT Masterplan was reviewed continuously by the school leadership to ensure that all the teaching staff were involved and coping in the process.

There were also initiatives to integrate ICT in both formative and summative assessment. A good example is the Enigma Project that has been undertaken by the ITAL Unit (Interactive Technologies in Assessment and Learning) in UCLES (University of Cambridge Local Examinations Syndicate). The project was a set of trials of online examinations conducted in
Singapore in September 1997 and October 1998. The trials were undertaken as part of Singapore’s desire to move towards a more ICT-based assessment system. In the first trial, the papers of a Physics examination were transferred directly into a computer form to consider whether a traditional paper and pen (multiple choice and short questions) could be administered through a computer. For the second trial, there were two components – conceptual and analytical. The conceptual component was similar to the first trial but the analytical component offered questions that were similar in nature to a Science practical examination that the candidates were expected to carry a simulation. The two trials showed that ICT-based assessment was feasible but there were many technical, administrative and educational issues to be addressed. These activities that interacted with the assessment process included the use of ICT for test administration, its use in setting questions, in manual and automated marking, support for teachers using ICT-related materials in the classroom and the role, use of provision of electronic content (Harding & Raikes, 2002).

Other initiatives included exploring assessment modes in the ICT-based learning environment to measure students' skills in assessing and applying information, thinking and communicating. While current modes of assessment remain relevant, ICT could facilitate assessment of pupil competencies across more than one subject area and in several skills. Such modes of assessment included project work, simulation software to assess students' ability to formulate and test hypotheses and self-assessment software for students to monitor their own learning.

**Lessons Learned and Recommendations**

- **ICT should be integrated into the schools to meet the curricula goals.** When ICT is perceived by teachers as tools to meet curricula goals, they are more likely to integrate it in their lessons.
- **Different types of ICT tools complement one another to meet curricula goals.** For example, the Internet may complement PowerPoint where students are first instructed to search for relevant information from the Internet and subsequently present their findings using PowerPoint.
- **Different ICT tools offer teachers with different opportunities to enhance the learning and teaching processes.** Teachers must be made aware of these opportunities and learn how to take up these opportunities in their lessons.
- **When ICT is employed in the learning environment, there will be a shift in teaching and learning strategies.** This will be elaborated in greater detail in the Issue 2 under this component.
- **Orienting activities that support learner autonomy help students to be more engaged in their learning.** Lim & his colleagues (2002) stress the importance of orienting activities in ICT-based lessons. These orienting activities include introductory sessions to ICT tools, advance organizers and instructional objectives, activity sheet and checklist, and ICT and non-ICT tools for post instructional reflections.
- **In order to facilitate the effective integration of ICT in schools, students must be equipped with a set of ICT skills.** This skill set may include keyboarding skills, information search and evaluation skills, word-processing skills, web-authoring skills, and other more specific ICT skills (such as image and video editing, and flash development).
- Effective integration of ICT in schools must consider integration issues into both the curriculum and assessment. Curriculum and assessment are interdependent and must be considered together, one supporting the other and consistent with the other.
- When ICT is introduced into the assessment process, there is a need to reconsider the assessment approaches. There may be a greater role for formative assessment when ICT is integrated into the assessment process.
- The role of the teachers in the integration of ICT in the school curriculum and assessment is pivotal.
- In order to carry out this role effectively, the sociocultural factors in the learning environment should support it. These factors include supportive leadership, professional development (both formal and informal) and access to ICT-based resources.

**Issue 2: Shift in Pedagogy, Redesign of Curriculum and Assessment, and Greater School Autonomy: From MP1 to MP2**

**Analysis of Strategies**

MP1 has given schools in Singapore a strong and broad base to integrate ICT in the curriculum and other school activities. There is now a basic ICT infrastructure, a starter pack of content and learning resources, a fair level of IT competency among teachers and students. More importantly, there have been changes in the pedagogical approaches adopted by schools. In the interviews conducted by IDA with principals, HODs and teachers in 2002 ([http://schools.s-one.net.sg/findings1.html](http://schools.s-one.net.sg/findings1.html)), the respondents noticed a shift towards more self-directed learning processes and learning environments that promote higher level of understanding of subject-matter. A few of them stated that through these changes in pedagogical approaches, a community of thinking and independent ICT-savvy students could be groomed for the future.

The shift in pedagogy is most noticeable when comparing the goals of MP2 to the present situation of ICT use in Singapore schools. The three main goals of MP2 are:

1. To redesign the curriculum to leverage new teaching methods made possible by technology and to fully integrate ICT into the curriculum. In contrast, under the first Masterplan, teachers mainly used ICT to support a given curriculum.
2. To move from a teacher-centred pedagogy when using ICT to a student-centred strategy.
3. To allow schools greater autonomy and flexibility in using ICT funds, unlike the current “one-size-fits-all” approach.

The key differences between the present situation (today) and the goals of MP2 (tomorrow) are outlined in Table 1.

<table>
<thead>
<tr>
<th>Today</th>
<th>Tomorrow</th>
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<tbody>
<tr>
<td>Use of ICT to support existing curriculum</td>
<td>Seamless integration of ICT at the planning stage of curriculum design</td>
</tr>
<tr>
<td>Largely static content in print form</td>
<td>A repository of dynamic digital content</td>
</tr>
</tbody>
</table>
One-size-fits-all approach | Mass customization and ability-driven approach
---|---
Teachers demonstrate basic skills and competencies in the use of ICT for teaching | Teachers demonstrate a range of competencies in the use of ICT for teaching
Phased approach in the implementation of ICT in schools | Schools have greater ownership and accountability in ICT implementation
Standard ICT provisions for all | Flexible ICT provisions for all
Predominantly practising teacher-centred pedagogies | Predominantly practising student-centred pedagogies

Table 1: Comparison of Present Situation and Goals of MP2.

These goals can be translated to six intended outcomes for MP2:

- Students to use ICT for active learning.
- ICT will be used to enhance the connections between curriculum, instruction and assessment.
- Teachers to use ICT as a tool for professional and personal growth.
- Schools to have the capacity and capability in the use of ICT for school improvement.
- There is active research in ICT in education.
- Creating a dependable and flexible infrastructure that supports widespread and effective use of ICT.

In order to fulfill these outcomes, the MOE has been incorporating the use of ICT into the planning, design and delivery of the curriculum. MOE is working with electronic publishers on a comprehensive repository of digital media content which complements existing resources like textbooks. This repository will allow teachers to use and customize the content to meet the learning needs of their students (Soh, 2002). Moreover, emerging technologies are being explored to increase the efficiency of summative assessments, and to expand the scope and nature of formative assessments. These changes will support a shift of pedagogy towards one that is situated in the social constructivist paradigm: one where students work together on learning tasks to co-construct knowledge with teachers scaffolding the process, mediated by ICT.

**This shift in pedagogy requires teachers to be equipped with a new set of skills, attitudes and knowledge to take on a pivotal role in the learning environment. Hence, there is need for a sustained model for the professional development of teachers in the use of ICT in education. This model should have clear benchmarks for the beginning teacher, the trained classroom teacher, the peer leader and the organizational leader. This model may be mediated by network technologies where existing training initiatives are streamlined and integrated with existing and new ones into a single e-learning system (Shanmugaratnam, 2002).**

Under MP2, ETD continues to work and explore with schools to make the most effective use of ICT to support their learning and administrative programs. Schools have more autonomy in the management of ICT-related resources than MP1, and will have access to clear performance indicators to help them to self-evaluate their ICT programs. ICT consultancy teams in each school cluster are also being formed to support these new initiatives that will encourage greater diversity of creative approaches and processes towards the integration of ICT in Singapore schools (Soh, 2002).
ETD has also started to work with the National Institute of Education (NIE) to conduct research in the use of ICT in education. Schools are encouraged to “generate research and development that will enhance the next generation of technology applications for teaching and learning” (Soh, 2002, p.32), and “teachers can look forward to R&D grants to help them experiment with novel teaching strategies and to develop new teaching and learning resources” (Shanmugaratnam, 2002). Such R&D efforts will keep Singapore at the forefront of education technology.

Lessons Learned and Recommendations

- In order to optimize the potential of ICT, there should be a shift in pedagogies, redesign of the curriculum and assessment, and more autonomy for schools. When ICT enters the school environment, everything in the environment has to change to take up the opportunities and address the limitations of ICT.
- A shift in pedagogical approaches of using ICT in education takes time. In Singapore, MP1 has provided a foundation (e.g., basic ICT infrastructure, ICT competent teachers, and clear vision) and necessary conditions for a shift towards more student-centred approaches of ICT-based lessons.
- A shift in pedagogical approaches may facilitate the building of a community of thinking and independent ICT-savvy students in schools.
- To facilitate a shift in pedagogical approaches, there should be a redesign of the curriculum and assessment, professional development of teachers, and research and development of ICT in education. The MP2 in Singapore has put in place these elements to facilitate the shift in pedagogical approaches towards student-centred approaches.
- The shift in pedagogical approaches should be consistent with the goals and underlying principles of the education system. In the case of Singapore, the ability-driven education system necessitates and facilitates this shift in pedagogical approaches.
- Investment into research and development projects and centres is important to examine existing pedagogical practices, revise and refine these practices, and explore new pedagogical approaches of ICT in education.

Issue 3: Content Development that Supports the Curriculum

Analysis of Strategies

MP1 set out strategies for acquiring and developing a range of software relevant to the local curricula objectives. Working with the Economic Development Board (EDB) and the National Computing Board (NCB), MOE provided the directions and specifications to ensure that the content developed was relevant to the school curriculum. EDB and NCB attracted leading global software houses to set up local operations, and form links and consortia with local software developers. Under the MOE-Local Industry Upgrading Program, local companies partnered with the established global software houses to develop educational software and facilitate the transfer of skills and technologies. The focus was on developing high quality software, especially in areas where suitable titles were lacking in the curriculum. NCB also helped to develop the base of talent required to produce educational software, and encouraged software distributors to
provide value-added services to schools, such as proactive sourcing of educational software to match their needs and provision of after-sales technical support.

These efforts have paid off and many locally developed educational software packages have been recognized internationally. One of them is the Active Primary Mathematics CD-ROM series comprising of three titles. It was the collaboration between MOE project development specialists, who are teachers by training, and Times Media Private Limited, an experienced publisher of educational books and software. The first two titles, 'In Rainbow Rock' and 'With Vroot and Vroom' have each won a Bronze World medal in the prestigious New York Festivals International Multimedia Competition in 1999 and 2000. 'In Rainbow Rock' also won the ComputED Gazette's 7th Annual Best Children's Educational Software Awards (BESSIES) in the Early Elementary Mathematics category. The BESSIES awards provide parents and teachers with a guide to the best children's educational software currently available in the retail market. The strengths of the series are its sound pedagogy, innovativeness and content-rich activities.

The MOE has a compilation of recommended software that has been evaluated by the MOE Clearinghouse for IT Resources (http://www.moe.gov.sg/edumall/edu_library/rsl_english1.html). Schools, however, had autonomy in deciding and purchasing the software they should acquire. Under the Educational Software Procurement Scheme (ESPS), schools could purchase any number of copies of any software titles in the ESPS list at a special educational price and directly from the locally appointed agent of the software publishers participating in the scheme. The ESPS was also extended to teachers. Under this scheme, each teacher, whether in primary school, secondary school, JC or CI, is entitled to purchase one personal copy of each software title at the special educational price. This scheme facilitated the use of educational software as a learning resource in the curriculum.

The Digital Media Repositories (DMRs) was established to provide media clips, web pages and courseware snippets for multimedia resource-based learning. The software industry was actively involved in developing and offering content and related services – (e.g., developing CD-ROMs and materials for the DMRs, identifying and mirroring relevant Internet sites, and sourcing off-the-shelf software from abroad). MPI envisaged the Internet becoming a key content and learning resource in schools with its increasingly vast amount of information relevant to education. The Internet served as a platform for delivery of materials in the DMRs. There was also established a database of Internet educational resources for use in the local curriculum (http://www3.moe.edu.sg/ier/).

Based on the interviews carried out by the IDA of schools in the FastTrack@School Project (http://schools.s-one.net.sg/findings1.html), the respondents identified a variety of courseware across all disciplines that were developed with the funding from the project. All subjects within the schools' curriculum were covered by the development through the FastTrack@School initiative. These developments ranged from applets and worksheets for academic subjects (e.g. applets in Physics: http://www.vjc.moe.edu.sg/fasttrack/physics/index.htm) to video clips and animation in humanities (e.g. animations in Geography: http://www.rvhs.moe.edu.sg/Learning/geography/rygeo.html) and special interest areas.
The respondents cited various reasons for the choice of the courseware developed with the FastTrack@School funding:

- The trend towards broadband interactive multimedia content for education (e.g. videos, simulation aids, and games) that had been found by research studies to be effective in enhancing students' understanding of subject areas;
- The belief that learning should be independent, fun, flexible and self-paced;
- The ICT tracking system for the auto-grading of quizzes might help students to reflect upon their attempts, and hence develop independent learning; and
- A value adding dimension to the creative processes of teaching and learning in all subject areas.

All these developments build up a rich and comprehensive repository of digital media content that complements existing resources such as textbooks, software and web-based resources. Moreover, the ICT-based resources developed from the abovementioned initiatives are more likely to be anchored to the local curriculum and context, and hence, increasing the relevance and authenticity of the resources for the teachers and students. MOE is spearheading the effort of creating this repository where teachers can access and customize the content based on the type of learners, learning environment and curriculum. This may then be integrated into a learning management system which students can access anywhere and anytime.

Lessons Learned and Recommendations

- Local development of ICT-based resources is crucial to support the curriculum. It increases the relevance and enhances the authenticity of the resources for the students and teachers.
- In order to develop high quality ICT-based resources, the MOE should attract well-established foreign education software developers to work with local companies. This will also promote the transfer of skills and technologies.
- The MOE may provide a recommended list of ICT-based resources (software and websites) based on its evaluation, and/or the evaluation of teachers and students who have used the ICT-based resources before. This will help the teacher to identify the most appropriate ICT-based resource to use for a lesson without spending too much time sieving through a pile of resources and evaluating them himself/herself.
- Besides providing a list of ICT-based resources, the MOE may also provide suggestions of how a particular website or software can be used in a lesson of particular subject matter. This will be especially helpful for novice teachers or teachers who are new to ICT in education.
- Schools should have the autonomy to choose the type of ICT-based resources they prefer to purchase or adopt. However, the MOE may negotiate with software distributors and other ICT providers to offer schools such products and services at special educational prices. The Educational Software Procurement Scheme (ESPS) in MP1 is a good example.
- Teachers must have access to ICT-based resources so that they can practise and plan for their lessons. The ICT Masterplan may promote such access by offering teachers a special price for hardware, software and Internet access.
- The MOE should develop and collate ICT-based resources that are made available to schools. The collation of these resources ensures that there is minimal duplication of development, and offers schools ICT-based resources that are the most appropriate to the local curriculum.
• The ICT-based resources should be customizable so that they will meet the needs of the teachers and students based on their context.
Component 7: Professional Development  
(Pre-service and In-service)

Issue 1: *Policy in Teacher Training on ICT*

**Analysis of Strategies**

An effective and continuous program for training teachers in the use of ICT to achieve curricula objectives was central to the success of MP1. As such, every teacher was trained to handle IT-based instruction and support new learning strategies among their students. A four-tier fan model was put in place to train teachers in every school in 1999. 60 Senior ICT Instructors from ETD formed the first tier of training, which was completed in late 1996. The Senior ICT Instructors then trained schools in Phase 1 of implementation, comprising 22 Demonstration schools. Heads of Departments (HODs) in charge of ICT and selected teachers from each of these Phase 1 schools then co-trained the teachers of three to four schools each, together with the Senior ICT Instructors, in Phase 2 of implementation. Selected HODs and teachers from these schools in turn trained those in the final phase of implementation. The fan approach generated a multiplier effect, enabling the sharing of expertise and experiences between schools. The HODs and teachers in the earlier phases who were selected as part-time instructors for other schools have their teaching duties reduced by about one-third. The Senior ICT Instructors played the roles of the key trainers, mentors and coordinators for all schools during the planned implementation.

The Masterplan also involved 'academic coaches' from the Institutes of Higher Learning (IHLs), ICT firms which have had association and expertise in education, and committed ICT professionals from the private and public sector. These participants formed partnerships with schools so as to lend their professional expertise, advise schools on their ICT strategies, and help assure a continuous flow of ideas and practices that could be used by schools. The different approaches to using ICT in various schools were a source of learning to all, both 'academic coaches’ and stakeholders of schools.

The National Institute of Education (NIE) aligned its teacher training programs to ensure that all trainee teachers have core skills in teaching with ICT resources. This required the effective integration of ICT into the NIE's own curricula, the training of all academic staff such that they would become role models in the use of ICT for teaching, and providing ready access to ICT tools and related resources for all trainee teachers. The first priority was to equip trainee teachers from the 1997/98 academic year with the basic pedagogical and technical skills required to integrate ICT into the teaching of school curricula subjects. ICT skill (e.g. PowerPoint, DreamWeaver, Excel) workshops were conducted on Saturdays by private ICT training
consultants to equip students with technical skills. For the core module on ICT integration in the pre-service teacher program, trainee teachers were expected to be able to:

- select, evaluate and integrate IT resources into lessons,
- design and create multimedia applications,
- manage and facilitate learning using IT, and
- evaluate strengths and weaknesses of IT tools.

The key elements of the core module are explained in Issue 4 of Component 7.

As the basic training in the Institute cannot be expected to prepare the teachers fully to the basic level of competency to integrate ICT effectively in schools, an induction programme is absolutely crucial. In Singapore, the MOE has a centralised induction programme conducted by the Teachers’ Network for new teachers that is dedicated to providing vital information, survival tips, platforms for discussion and sharing among beginning teachers, and between beginning teachers and more experienced ones in face-to-face and electronic environments. This applies to both ICT-based and non-ICT-based tasks carried out by the teachers. Individual schools also have their own school-based induction training to introduce the new teachers to their particular school culture and ethos. The new teachers are assigned to a personal mentor in school to guide them through various issues and problems of teaching and learning in the school.

Through much fine-tuning by the MOE and teachers’ training agencies, the transition from initial teacher education to induction is moving towards being seamless. This transition is also becoming seamless from induction to in-service continuous professional development and networking. The teachers in Singapore have various opportunities to constantly refresh their skills and knowledge to keep up with the latest developments in education, both pedagogies and technologies. The MOE and the teachers’ training institutions usually provide these opportunities. Teachers are entitled to 100 hours of in-service professional development each year. Teachers are also fully sponsored or highly subsidised for courses, conducted by private training agencies that enhance their professional competence.

In Serangoon Garden South School (http://schools.moe.edu.sg/sgss), the administration has developed the Needs Training program to cater to teachers’ development of ICT and pedagogical skills. Teachers who wanted to know how to use any hardware or software in school would submit a Needs Training form to the HOD (ICT). An appointment would then be set up between the trainer (HOD(ICT) or ICT committee members) and the teacher for a suitable time to conduct the Needs training. In this way, more personal attention and time could be devoted to the teacher in need. Such peer coaching has been very effective in the school as it focuses on the pedagogical and technological learning of the teachers in the context of the school.

Based on a survey by Soh (2002), all teachers had received 30 to 50 hours of ICT-related professional development. The majority of the teachers (84%) had expressed their interest in further ICT training above the required minimum. 77% of teachers wanted to find more ways to integrate ICT into education. 68% felt that ICT had encouraged more participation in class, while 65% found the preparation of ICT-based lessons worthwhile. Given such positive perceptions of the teachers towards ICT in education, the professional development program seemed to have cleared the initial hurdle of resistance and apprehension.
Lessons Learned and Recommendations

- The ICT professional development program for teachers must plan for the continuous training of teachers – from pre-service teacher education to induction to in-service professional development.
- The fan-approach of the initial ICT training of teachers in schools had been an effective approach of professional development in Singapore. It ensured that teachers were trained in the context of their workplace by their more experienced peers from other schools or senior instructors from ETD. Moreover, best practices were shared and team-teaching based on the apprenticeship model was practised. Therefore, the fan-approach of professional development should be considered by other countries that are embarking on their ICT masterplan in education.
- The ICT professional development program should focus on both pedagogical and technological aspects of ICT integration.
- Training agencies (including MOE, teacher education institutions and private companies) should adopt a systems approach to the change process. A good example is the approach that has been adopted by NIE. It first identified all functions of the institution, including hardware and software infrastructure, human resources development, support systems, research and development, and policy before designing and implementing change strategies for all these functions.
- Faculty professional development in the teacher education institution is crucial to the success of the pre-service education program in ICT. There is first a need to re-examine the existing training model with regard to objectives, methods, costs, and effectiveness. This may be followed by designing a new or revised training system that includes informal support so that less experienced faculty can get just-in-time help from those more experienced ones. That may also be a need to provide incentives, such as workload reduction, recognition in faculty evaluation, and increasing research fund allocations to those who spend time training other faculty or who actively use ICT in their teaching (Jung, 2000).
- Division of labor among different training agencies, with central coordination from the MOE, should be practised. The MOE and the teacher education institutions will not be able to address all the training needs of the teachers in schools. There is a need to sub-contract certain courses out to private training companies and other IHLs. However, an important point to note is that the MOE and schools must work very closely with these agencies to design a training curriculum that is relevant to the teachers.
- Just-in-time learning should be an integral part of the professional development of the teachers. One good example is the peer coaching program in Serangoon Gardens South School.
- Continual professional development of teachers should be an entitlement for them. The 100 hour training entitlement of teachers in Singapore ensured that teachers were kept updated. Based on the survey by Soh (2002), teachers in Singapore devoted 30-50 hours a year to ICT-related training.
Issue 2: Need for ICT Competencies and Standards Before Training

Analysis of Strategies

ICT not only mediates lifelong learning in schools, but also extends learning beyond formal classroom settings and provides practice with self-directed investigations as individuals move into internships, first professional positions, and increasing responsibilities in all arenas of life. Therefore, ICT competency among teachers and students is not only a mediating element; it is also a desired outcome of effective ICT integration. Given the high ranges of both the teacher use and student use among the different phases of schools in the self-reporting questionnaire, there is a need to set ICT competency standards for teachers and students. The standards set may be in both technical and pedagogical ICT competencies that are customizable to the context of each school.

Although ICT competency standards for students and teachers at each level have not been stated under MP1, one of the project teams in MP2 has been examining the relevance and justification of the ICT competency standards that have been used in other countries. The team is in the process of formulating a set of ICT competency standards for students and teachers as a guideline to schools.

Lessons Learned and Recommendations

- The application of ICT competency standards allows teachers and students to seamlessly integrate learning materials from a wide range of sources. This promotes the development of learning environments that are tailored to the individual needs of students.
- Although setting ICT competency standards mediates the effective integration of ICT in schools, there is a need to ensure that these standards do not become an additional pressure for students and teachers. The teachers and students should be scaffolded in the process of achieving the ICT competency standards.
- Moreover, the ICT competency standards that are set at the national level should be customized for use in each school, depending on its sociocultural context.
- The ICT competency standards should avoid software or product-specific skills. Instead, the standards should focus on generic skills of particular applications. For example, the standards should look at word-processing related skills rather than Microsoft Word 7.0 related skills.

Issue 3: Content Focus of Capacity Building for Pre-Service Teachers

Analysis of Strategies

NIE worked very closely with ETD and schools to design the ICT component in the pre-service teacher education program. It closely examined the vision, dimensions and strategies of MP1 before developing its ICT training plans for pre-service teachers. Four types of ICT courses for NIE trainee teachers were put in place for the pre-service teacher education program: basic skill
ICT workshops, 30-hour ICT foundation course, 26-hour elective courses, and 6-12 hours of ICT integration into each curriculum subject class. The foundation course focuses on hands-on ICT experience at the initial stage of pre-service teacher training. The course acquaints trainee teachers with the art of integrating ICT in schools. This course is supported by basic ICT skills training workshops that have been sub-contracted to private training agencies. The agencies conduct workshops on Powerpoint, Dreamweaver, Flash, Excel, Authorware, and other applications for the trainee teachers during the term breaks and on Saturdays.

For the elective courses, more advanced ICT-based pedagogical principles and skill set are offered. Examples include “Constructivist Learning with the Internet” and “Instructional Multimedia Design”. Besides these courses, there is also an ICT component integrated into all subject areas such as Mathematics, Science, English, and Humanities. For all these courses, students have the opportunities to design and develop ICT-based instructional plans and resources, and share their ideas and products with their peers. Moreover, the trainee teachers’ practicum has been used as an opportunity to collaborate with schools to upgrade the trainee teachers’ ICT-integrating skills. During the practicum, trainee teachers are encouraged to design ICT-based lessons and implement them under the close supervision of expert teachers and NIE lecturers in the schools.

The focus of this section is on the ICT foundation course. The core module on ICT integration in the pre-service education program focuses on the pedagogies of using ICT in the classrooms. The tutors employed a fully dynamic online learning environment to complement onsite activities for this module. In 2002, there were four major components in the module: anywhere/anytime lecture, onsite laboratory tutorial, online independent hands-on session, and online asynchronous discussion. Besides the introduction of these new components, there was also a shift in the mode of assessment from summative to more formative, and a shift in the methods of delivery from cognitivist-oriented to social-constructivist-oriented (Lim, 2001a). The anywhere/anytime lectures were designed to complement textbook readings. The tutors co-authored a book ‘Teaching and Learning with Technology’ (Tan & Wong, 2003) to highlight and address key issues of ICT integration. The online lectures consisted of instructional objectives, dynamic guiding questions and reflective activities (such as online quizzes and hyperlinks to case studies) to enhance task-orientation and encourage critical reflection among trainee teachers.

During the onsite laboratory tutorial, there was no didactic teaching and less discussion of textbook concepts (these discussions were carried out in the online discussion board). Instead, these tutorials focused on collaborative activities where groups of trainee teachers worked together on tasks. The tasks were always posted on the module website two weeks before the tutorial session. During a tutorial session, for example, trainee teachers evaluated the strengths and weaknesses of ICT-based resources as a group and presented their findings to the class. These reports were then uploaded onto the File Exchange of the learning management system to be shared among trainee teachers.

To encourage greater learner autonomy, there were also independent online sessions. These sessions required trainees to work independently on various challenging tasks. These included identifying the learning opportunities and problems associated with the use of IT tools within the
school context, critiquing visual aids posted by their fellow trainees or tutors, and reflecting and commenting on video clips of classroom management issues. They were also given the opportunity to work with their partners, as well as classmates, bounce off ideas and explore ICT resources. The activities of such sessions were well-structured to provide scaffolding for them to manage the tasks and their time.

Trainee teachers were expected to participate in intra- and inter-group online discussions. The online discussions allowed them to apply what they have learnt to their own learning and teaching experiences. By sharing their experiences and expertise of ICT integration in schools, they distributed a part of themselves in the module website. As Vygotskian and Deweyan traditions suggest, we do not learn in isolation from others. Discussions among students, and between students and teachers promote the guided construction of knowledge in the learning environment (Lim, 2001b). Moreover, such asynchronous discussions encourage critical reflection among students. That is, students can reflect on a posting before replying to it. To date, the module has undergone considerable change to meet the changing needs of the education system and schools.

**Lessons Learned and Recommendations**

- The ICT professional development program of teachers should be planned based on the vision of the ICT Masterplan. In order to achieve this, the various agencies involved in the professional development program should work in close consultation. In Singapore, the close collaboration between NIE and ETD helps the former reflects upon national visions and secure budgets for innovations.

- The foundation course on ICT integration in the pre-service education program should focus on applying ICT skills to achieve pedagogical objectives, rather than teaching ICT skills in isolation. That is, ICT skills should be learnt within the context of classroom objectives and activities.

- There should be a multi-prong approach when developing ICT-related skills in pre-service teacher education. In the case of NIE, four types of ICT-related courses have been offered: basic skill ICT workshops, the ICT foundation course, elective courses of advanced ICT-based pedagogical skills, and ICT integration into each curriculum subject class.

- The pre-service teacher education institution should collaborate with private or public ICT training agencies to equip trainee teachers with the basic ICT skills. These agencies are specialists in ICT training and may be more competent and effective in the training. The teacher education institution can work closely with these agencies to develop the curriculum of the workshops, and leave the training to the latter. Hence, the teacher education institutions can focus on the pedagogical use of ICT for education.

- The pre-service education program should incorporate various modes of instructions into its courses, especially the ICT-related ones. In the case of the foundation course in NIE, it has complemented face-to-face tutorials with independent online learning. This allows trainee teachers to experience different modes and strategies of instructions, especially the online ones.
Issue 4: Documenting and Monitoring Capacity Building of All Educational Personnel and at All Levels

Analysis of Strategies

In order to document and monitor the professional development of all educational personnel under the MOE, the Training Administration System (TRAISI) was developed in 1999. It was designed and developed by Andersen Consulting in association with MOE's Staff Training Branch. TRAISI is an online system on the Intranet that enables both teaching and non-teaching staff of MOE to document their own Individual Training Roadmaps. It allows staff to source for training courses from the online MOE and Institute of Public Administration and Management (IPAM) prospectuses and apply for the courses online. The system then informs the staff of the outcome of their application via fax or e-mail depending on their preference. TRAISI is also able to help track training status and generate reports on training statistics.

Lessons Learned and Recommendations

• All educational personnel at all levels should undergo professional development of ICT-related skills. It should not be confided only to teachers or HODs. The non-teaching staff in MOE complement and support the teachers in the integration of ICT in their schools.
• A centralized training administration system for all teaching and non-teaching staff is crucial to document and monitor their professional development. This system must be accessible to all staff via the Intranet or Internet so that they can track and monitor their own professional development, and plan and apply for the courses that they need to attend. Such a system will not only help the supervisors monitor the professional development of their staff, it will empower the staff to reflect on and plan for their own professional development.

Issue 5: Incentive System and Motivational Strategies for Teachers (Accreditation and Certification, etc.)

Analysis of Strategies

Hewlett-Packard (Singapore) has sponsored the HP INIT Award since 1999, to recognize teachers’ creative use of ICT in teaching. This award encourages teachers’ innovation in applying ICT to enhance their students’ learning, and motivates teachers to move on to higher levels of ICT use. In 2001, a new dimension was added – collaboration and networking among teachers and specialists. The new dimension provides teachers with a platform to reflect on their own learning experiences through the innovative use of ICT, backed by strong pedagogical considerations.

NIE has also established a set of Advanced Diploma and Advanced Postgraduate Diploma in Education programmes to enable teachers to upgrade and keep up-to-date in their content knowledge of school subjects or state-of-the-art educational methodologies or technologies, guidance and counselling methods or educational administration courses. The Advanced
Diploma in Information Technologies in Education has already taken in three cohorts of teachers. These advanced diplomas then provide an alternative route for admission into the institute’s bachelor’s and master’s degree programmes. The teachers, however, can opt to sign up for individual modules in the programme, and hence, having a wider choice of in-service continuing professional development. The advanced diplomas and their accreditation framework also ensure better articulated linkages between in-service and career paths of teachers by providing greater opportunities for serving teachers to upgrade to degree and postgraduate qualifications, even at doctoral level.

**Lessons Learned and Recommendations**

- There should be a recognition system for innovative and effective use of ICT integration in schools. This may be in the form of awards or grants for teachers, HODs or principals. It may be at the school level, cluster level or national level.
- These awards may be sponsored by private companies and organizations that work closely with the MOE, schools and higher education institutions.
- Formal certification of in-service professional development that leads to diplomas or degrees may provide the incentive for teachers to upgrade and update their skills and knowledge in ICT integration.

**Component 8: Monitoring and Evaluation**

**Issue 1: Documentation of Benefits of Using ICT in Education**

**Analysis of Strategies**

In the research by IDA in 2002 ([http://schools.s-one.net.sg/findings1.html](http://schools.s-one.net.sg/findings1.html)), the interviewees stated that the implementation of FastTrack@School had enhanced their teachers’ ICT integration capacity and their students’ learning processes. The teachers, HODs and principals in the interviews shared about how ICT mediated the learning processes to engage their students in their learning:

- Interactive multimedia courseware facilitated teaching and learning of abstract ideas and theories.
- ICT afforded self-directed and self-pace learning on the part of the students. There was no time constraint and students were able to achieve greater autonomy in learning.
- The integration of ICT in lessons had been a catalyst to boost students’ self-confidence. One example cited was the use of ICT in presentation as part of the course requirements. The students benefited tremendously throughout the different phases, from preparation to the final delivery of the presentation.
• ICT facilitated discovery learning that encouraged students to ask and address more in-depth questions. However, such an approach might require more time than traditional approaches.
• ICT stimulated young students’ sensory and cognitive curiosity. Most of these students were visual learners and the use of vibrant colors, interactive graphics and icons in the courseware provided the stimulation.
• The development of interactive courseware could involve students. When students are engage in the design and development of multimedia, they acquire a set of life skills in the process. An example of such student participation in courseware development was at Victoria Junior College. The students were so enthusiastic and motivated that many who had graduated from the college returned to assist in various developmental projects.

The interviewees also shared about how the ICT initiative by IDA and MOE enhanced the ICT integration capacity of teachers:
• The deployment and use of ICT for training and teaching had raised the level of ICT awareness and ICT competency level of teachers.
• Although ICT would never replace a real-life teacher, the ICT resources complemented existing academic resource materials to enhance learning.
• ICT facilitated the exchange of knowledge and resources among the teachers. These ICT tools included both asynchronous and synchronous communication tools. This ensured knowledge-base connectivity amongst the teachers.
• Peer teaching and sharing were practiced in many schools. Those who were more experienced in ICT integration mentored and shared with those who were less experienced. This had fostered a healthier work culture amongst the teaching staff.
• The ICT initiatives provided the teachers with opportunities to explore beyond the boundaries of their academic area. In designing interactive multimedia courseware, they had the opportunities to work with the respective vendors and develop instructional design and technical skills.

Besides the interviews carried out by IDA, there were also projects that focus on documenting the benefits and processes of ICT integration in Singapore schools. They included the projects under the edu.QUEST initiative and research projects carried out by NIE under the Education Research Fund. This section will be describing the former, and the next section will describe the latter. edu.QUEST was an initiative of the MOE. It showcased research projects on the use of ICT in education (http://www.moe.gov.sg/edumall/edu_quest/eduquester/default.htm). Projects in edu.QUEST focused on quality research into the impact of leading edge technologies on educational practices and achievements. Under the umbrella of edu.QUEST, action research was carried out in the Singapore-Apple Collaboration (SAC) Project. Action research was chosen as the research design to be responsive to the unanticipated discoveries that were made in the experimentation with emerging technologies.

The teachers, HODs and principals in the SAC participating schools engaged in action research to create the time and space to think about fundamental issues related to using technology for teaching and learning. They asked questions about real issues in the classroom and reflected
upon them to bring about improvements. Both qualitative and quantitative methods were employed in most of the research projects to enhance validity and reliability. One of the projects was carried out in Woodlands Primary School on the use of wireless technologies in Science classrooms – “Turning the Science Garden into a Huge Classroom” (http://www.moe.gov.sg/edumall/edu_quest/eduquester/sciencegarden.html). The teacher turned the school science garden into a huge outdoor classroom using wireless iBooks where students studied the plants in their natural environment, and surfed the WWW on the spot to engage in further research of the plant. The teacher evaluated the project and found that:

- Students could relate easily what they have observed in the Science garden to what they have read on the Internet.
- Students were on task, asked relevant questions and compared observations/findings with their peers to see if they were on the right track.
- The learning environment was more interactive and responsive as the teacher could work with individual student or group. Immediate feedback and adaptive instructions were possible.
- The Network Assistant package allowed for better management of tasks and students. For example, students’ screens could be monitored and frozen.

Another project under the SAC initiative carried out in Marsiling Secondary School was marrying conventional mathematics trail with wireless technology and making it a wireless mathematics trail (http://www.moe.gov.sg/edumall/edu_quest/eduquester/mathematicstrail.html). The e-Trail consisted of four phases:

1. Pre-e-Trail: The teacher first decided on the e-Trail stations within the school compound and designed appropriate activities;
2. Start of e-Trail: The teacher set up the teacher station that would be the control hub, and briefed the students on the objectives and rules of the e-Trail;
3. The e-Trail: The students reached the station and activated their assigned passwords for authentication by the teacher before proceeding to answer the questions that the teacher has uploaded.
4. At the end of the e-Trail: The teams reported back to the teacher station. The winning team would be the one that completed all the e-Trail station at the shortest possible time with the most correct answers.

In the project, the teacher observed that the e-Trail fuelled a greater interest in the learning of Mathematics. It enabled students to apply their understanding of mathematics concepts to solve authentic problems in natural settings. Most of all, he found that the e-Trail has increased his students’ competency and confidence in using ICT in learning Mathematics.

**Lessons Learned and Recommendations**

- ICT tools offer students various learning opportunities in schools. These tools offer students with opportunities for learner autonomy, visualization of abstract concepts and relationships, experimentations and conduct of inquiries with simulation packages, and joint-construction of meanings among students and teachers.
- ICT tools also offer teachers with various teaching and learning opportunities in schools. The teaching opportunities are similar to the learning opportunities for students. The learning opportunities include collaboration and sharing of resources, expertise and experiences among teachers, anywhere-anytime professional development with teacher
training colleges and universities, and learning beyond the boundaries of their subject specialization.

- Research studies should document the process of effective ICT integration. It is only by doing so that best practices can be teased out and shared among practitioners and policymakers.
- One possible research design may be action research where practitioners explore and integrate ICT into the school curriculum, reflect on the process and outcome, and amend and refine their practices for future practices.
- Other possible research design may be collective case studies where intensive observations, interviews and collection of school documentation are employed to describe and interpret the activities that facilitate or constrain the integration of ICT in schools. Such a design is described in greater detail in the next issue.

**Issue 2: Program Evaluation**

**Analysis of Strategies**

Various local and international research studies have been carried out to study the state of ICT integration in Singapore schools. One of the first international studies conducted was the first module of the Second Information Technology in Education Study (SITES) by the International Association for the Evaluation of Educational Achievement (IEA) in November 1998 ([http://www1.moe.edu.sg/press/1999/pr991122.htm](http://www1.moe.edu.sg/press/1999/pr991122.htm)). The main objective of the study was to assess the status of ICT in schools for instructional activities by teachers and students in 27 countries that included Canada, Finland, Israel and Japan. For ICT infrastructure, Singapore was one of the leaders in the provision of computers and associated peripherals to the schools. Students have the opportunities to use data manipulation software, interactive CD-ROM packages, and Internet-related applications. A well-planned and implemented staff development program put Singapore as the top in this category. This included a high percentage of schools indicating that the provision of training for all teachers in using ICT for educational purposes. Moreover, the teachers learnt these skills and knowledge through more avenue than other countries; these avenues included ICT courses, training given by HODs and peers, and sharing sessions among schools. The findings also indicated that school principals in Singapore favored more ‘emerging’ ICT-related objectives than ‘traditional’ objectives in formulating their policies. Therefore, all these findings suggest that the conditions for effective integration of ICT in favorable.

In September 2001, a survey was conducted by the MOE (Singapore) that highlighted significant progress in ICT integration (Soh, 2002). Table 2 shows the main findings of the survey.

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<th>Main Findings</th>
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<td><strong>For the students</strong></td>
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improved their learning and encouraged them to learn beyond their curriculum. 64% of students also felt that ICT had simulated interaction with their classmates.

For the teachers

Every teacher had received 30 to 50 hours of ICT training. The majority of teachers (84%) have also expressed their interest in further ICT training above the required minimum. 77% of teachers wanted to find more ways to integrate ICT into education. 68% felt that ICT had encouraged more participation in class, while 65% found the preparation of ICT-based lessons worthwhile.

For the schools

A supportive culture for the use of ICT was being cultivated in most schools. ICT was effectively harnessed to support a variety of school processes, including administration, counseling and communication. Technology was a prevalent feature.

For the community

Students participated in projects with overseas students. Parents, industry experts and academics were roped in to make meaningful contributions. Partnerships with industry partners were now common. They helped exploration of new technologies, created new IT-based resources and provided training to teachers. The bonds between schools and the community were also strengthened through increased interaction and communication.

Table 2: Main Findings of Survey Conducted by MOE in 2001 (From Soh, 2002, p. 33)

In year 2000, a three-year research project under the Education Research Fund was carried out by NIE to examine and analyze where and how ICT had been integrated in Singapore schools to engage pupils in higher order thinking. The title of the project was: “Effective Integration of ICT in Singapore Schools: Pedagogical and Policy Implications”. The research study consisted of two phases: Phase 1 was a questionnaire survey of Singapore schools to explore the critical aspects of ICT integration; and Phase 2 was a collective case study of 10 schools that were chosen based on the degree of ICT integration in Phase 1. There were three main purposes of Phase 1:

1. It provided a descriptive and interpretive account of the critical aspects of ICT integration among Singapore schools;
2. It formulated recommendations to facilitate the effective integration of ICT in Singapore schools; and
3. It identified the schools for the collective case study in Phase 2. Ten schools (five primary schools, three secondary schools, and two JC/CIs) were chosen based on their degree of high ICT integration.

The questionnaire developed by the research team consisted of five categories: school ICT culture, student use, teacher use, management of ICT resources, and staff development. A more detailed description of the five categories is as follows:
1. **School ICT culture**: This referred to six items – school ICT policy, leaders use of ICT and their encouragement of staff use, collegial exchanges of knowledge and experiences with ICT, encouragement given to experimentation and innovative use of ICT, review of school ICT program, and involvement of staff in the review.

2. **Student use**: This included the following five items – proficiency in the use of ICT, types of learning with ICT, promotion of higher order thinking mediated by ICT, involvement in collaborative work mediated by ICT, and type of learning in ICT-based collaborative work.

3. **Teacher use**: There were four items – proficiency in use of ICT, integration of ICT in classroom practices, use of ICT to promote higher order thinking, and types of collaboration among teachers through the use of ICT.

4. **Management of ICT resources**: This included two items – teachers’ and students’ access to ICT resources, and monitoring of the use of ICT resources to promote optimal use.

5. **Staff development**: This referred to two items – learning opportunities for ICT integration, and review of staff development opportunities to meet professional needs.

A five-point scale was used as a rating scale for the responses of all items in the five categories. For example, under the item of school ICT policy, the descriptions were 1 for “No school policy on the use of ICT”, 3 for “School policy in some areas that is adopted by some staff”, and 5 for “Established and comprehensive school policy in many areas that is adopted by most staff”. The descriptions were provided for the extreme points and middle point of the scale. This ensured a more elaborated scale, but at the same time, reduced the cognitive load on the respondents. The three-point description was applied to all items in the questionnaire: point 1 of the scale was associated with no or little integration of ICT, point 3 was associated with moderate integration of ICT, and point 5 was associated with high integration of ICT.

Phase 2 was a collective case study of 10 schools (5 primary, 3 secondary and 2 junior colleges). The sample of schools at each level was chosen based on their high degree of ICT integration that were reported in phase 1. The case study was the most appropriate methodological tradition, given the aims of the study that emphasize the context of use. To gather accounts of different realities that have been constructed by various groups and individuals in the learning environment, both qualitative and quantitative methods were drawn upon: observations of ICT and non-ICT based lessons, face-to-face interviews with principals and ICT-coordinators, focus group interviews with students and teachers, questionnaires for teachers and students, and samples of students’ work.

This paper will not be reporting on the findings of any of the phases as the project will not be completed until the end of 2003. However, readers may want to access the project website at [http://eduweb.nie.edu.sg/projects/itintegration](http://eduweb.nie.edu.sg/projects/itintegration) for updates.

**Lessons Learned and Recommendations**

- In all planning and implementation of program and initiatives, the evaluation phase is very important. This should include both formative and summative evaluation where there is a continuous cycle of planning, implementation, reflection and refinement.
The evaluation should be carried out in a naturalistic setting across a whole range of school types and levels. This will provide a holistic picture of the ICT integration in schools.

Qualitative and quantitative methods should be employed to complement each other to enhance the validity and reliability of the evaluation. They also ensure that depth and breadth of the study are not compromised.

The findings of the evaluation must be interpreted and analyzed to inform pedagogical practices and policy planning and implementation. For the former, the findings may serve as a start-up kit or guidebook for teachers or principals in the integration of ICT. For the latter, the findings may provide policymakers with a better idea of how education policies facilitate or constrain the integration of ICT in schools.

The findings of the evaluation must be interpreted and analyzed based on well-established literature on education research, learning theories, management theories and ICT research. This will provide the study with multiple perspectives.