ICT Implementation in Education

An analysis of implementation strategies in Australia, Canada, Finland and Israel

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INTRODUCTION

The objective of the present study is to define the criteria that appear to determine successful implementation of ICT (Information and Communication Technology) in primary and secondary schools. A preliminary analysis of implementation strategies was carried out through contacts with national and European authorities in the four countries selected for the purposes of this study: Australia, Canada (Quebec), Finland and Israel. Initially each country was asked five questions concerning organisational aspects of the education system, ICT implementation objectives, resources and strategies, implementation phases and budget, and means of assessment to evaluate resulting changes. In most countries, this led to an ongoing dialogue with educational authorities. The survey was then followed up by a questionnaire addressed to one or more schools in each country considered to be successfully implementing ICT, in order to examine the practical issues at stake at all levels of education from K1 - 12.

When analysing successful ICT implementation, it is first necessary to define "success" in terms of ICT integration in education. Does success refer to the level of ICT integration achieved across the curriculum in everyday teaching practice, or does it refer to the level of ICT literacy that school leavers have attained? Should it be interpreted as the realisation of the learning objectives laid down in national implementation policy and translated into learning outcomes in study programmes? This is a question that was repeatedly asked by schools participating in the survey. The study shows that the earlier tendency to measure the degree of ICT implementation by student to computer ratio has now given way to more **qualitative measures of ICT applicability, accessibility** and **connectivity.** Indeed, both Canada and Australia warn against the danger of placing too much emphasis on the amount of equipment available, to the detriment of quality and equity of access, and a sound pedagogical basis in ICT use. Nevertheless, most countries did include ratios in their data. If the level of ICT literacy is to qualify success, how is this to be measured? The drive for ICT literacy has led to the introduction of "computer drivers licenses" in both Finland and Australia, but in Australia attention is drawn to the fact that two levels of computers skills exist, and that most pupils will attain the first level outside of school anyway (see DETYA report[1] and definition of **Basic** and **Advanced skills** in Annex).

The third success criterion has been somewhat neglected to date. A report produced in Canada this month[2] decries the **almost total absence of research proving the efficiency of ICT in improving school results**. It adds however, that an improvement in behaviour, attitudes and capacities of students in ICT rich environments have been noted, as well as greater autonomy, collaboration, more sustained efforts and more personalised teaching. In the present report, underlying educational objectives of each country and of participating schools are examined. These mainly focus on such aspects as **citizenship, collaboration, critical thinking, problem-solving and communication skills**. Understandably, few schools are able to give an estimation as to the degree of achievement of such objectives.

ICT integration in education has led to a number of evolutions in curriculum delivery and lesson content that are outlined in the report. Finland, for example, is developing a form-free, modular approach for the last two years of secondary schooling, enabling students to tailor part of their own study programme by choosing suitable courses in other schools or vocational institutions and passing them in any order, sometimes without having to physically attend lessons. Another content innovation introduced into the secondary curriculum is 'Media education', which aims at developing citizenship by educating students to understand and judiciously implement media sources.

The findings described in this study above all underline the profound evolution that took place in national ICT implementation strategies over the last years of the second millennium. From the multitude of euphoric pilot projects born of the late eighties/early nineties, most countries now seem to

have turned to a more **long-term, bottom-up approach** with strategies involving all **four key levels** of the educational system - national and local educational and training authorities, schools, teachers and students. An innovative measure in national ICT strategies is the **partnerships** that are being formed with **the local community** and **the business sector** as a supplementary source of expertise and finance in the drive for more successful implementation. ICT is obviously no longer dealt with as an add-on for high achievers or a more personalised approach for students with learning difficulties or lacking motivation, but rather as another **essential aspect of literacy** and as such is generally being **integrated as a tool across the curriculum**. **Equity of learning opportunities** is a further issue that is increasingly becoming a major area of preoccupation throughout the world. According to a report from Australia, Internet access is broadening the digital divide between rural and city schools, nationals and immigrants, boys and girls.

Focus is obviously still turned to initial and in-service teacher training, as the realisation has dawned that mastery of new technology as an add-on is certainly not enough to **prepare teachers for the pedagogical shift** inherent to incorporating new technologies in the teaching and learning process. In a report released this month, the Education Ministry of Quebec draws attention to the **scarcity of teacher trainers** able to combine the pedagogical and technological expertise necessary to respond to this need. It further underlines the importance of **peer learning, and hands-on support and development opportunities for teachers** through virtual learning and practice communities if pedagogically sound ICT integration is to be achieved.

These are some of the aspects that will be examined in the following pages, from the viewpoints of national ICT implementation authorities and individual schools striving to succeed the challenge of successful integrating ICT in education in the coming decade.

Quebec, CANADA

Canada is generally considered to be one of the world's leaders in ICT integration in education. It has one of the most favourable pupil:computer ratios (6.5:1) and all primary and secondary schools have access to Internet. The present analysis of national strategies concerns only Quebec, though two schools are examined in the following section, one in Quebec and the other in Alberta.

The national vision states that: *ICT contributes to developing intellectual skills, problem-solving abilities and communication skills. It aids in the development of a solid, multidisciplinary approach to learning and the mastery of skills necessary for the selection, processing and analysis of information, enabling pupils to develop critical thinking skills directly linked to using ICT (word processing, spreadsheets, graphic applications…) and to navigate on telecommunication networks. These skills underlie the capacity of students to learn "differently".*

National policy is based on the belief that four parameters determine the efficiency of ICT integration: the philosophy underlying the use of ICT (shared vision), the implementation strategies defined, the information technology actually available and evaluation methods. Two fundamental aims play a determining role in implementation strategies: make ICT a veritable tool at the service of teaching and learning, and place teachers at the heart of the action by allowing them to choose the aims and means whereby their teaching will evolve. In view of these aims, strategies focus mainly on learning content for pupils and teachers, equipment, training, innovation and research, and pupils' needs as well as the objectives and means promoted by the teaching team. All efforts are made to encourage pupils to continue their auto-training in ICT, which is now well underway. Quebec has opted for a project-based pedagogy, and to this end software and banks of data, maps, texts and pictures are continually being developed.

Implementation strategies involve three key levels:

1. Schools

Each school must formulate its own ICT integration plan (school plan). This plan sets out how the school, in collaboration with the school commission, intends to plan and organise ICT implementation, notably assuming the responsibility of training teachers and acquiring equipment and pedagogical material. A ministerial team and a web site have been set up to support the efforts of schools[3]. National aid for the creation of the school plan includes:

- access to relevant official documents published by Education Ministry
- guidelines for the acquisition of equipment (budgetary regulations and admissible purchases)
- e-mail contact for schools with experts in the field
- a complete guide on drawing up a school plan
- a repertory of over 100 school plan-related comments
- examples of plans for integrating ICT into teaching establishments.

Teachers play a key role in drawing up the school plan, selecting the means necessary to bring about the desired profound evolution in their teaching practice and the mode of application of these means. First they are called on to examine their own competencies in order to define and integrate the necessary changes in their methods. The school administrators and commissions set the priorities in ICT integration, and attribute their budget accordingly.

The Ministry relies on school plans for most of its interventions, fully respecting the rate of assimilation of technology by the school personnel and contributing to the efficiency of the actions undertaken by the school. A support programme consecrating an annual budget of 60 million dollars

(70 % paid by the Ministry and 30 % by Quebec's 70 school commissions) aids schools to purchase computers and link up to Internet[4].

2. Ministry

The Ministry is in charge of coordinating projects, in accordance with the priorities of all parties concerned. It is also responsible for promoting the development of contents, making necessary adjustments in terms of equipment, and inviting organisations from the public and private sector to contribute. Measures adopted by the Ministry to facilitate ICT integration include:

- ongoing evaluation with its partners of the potential of ICT as a teaching/learning tool, making adjustments to the curriculum when necessary; modification of evaluation practices in order to enable teachers to use ICT in their teaching;
- telematic networks used to disseminate to teachers pedagogical documents such as curricula, definitions of subject areas, information on school organisation, study programs, etc.;
- an annual $2 million budget is invested in computer and telecommunications equipment and content, in collaboration with the private sector for equipment and general-purpose programs;
- donates ICT equipment no longer used to schools, and encourages the private sector to do likewise;
- provides government grants to promote content development, supports a content evaluation programme as well as the elaboration and dissemination of pedagogical content designed for the information highway by partners in all educational sectors;
- allocates an annual budget for the maintenance and development of the RTSQ network (Réseau de télématique scolaire québécois);
- supports the creation of an education server in Quebec which will promote direct communication between partners and simplify searches for educational information from the global information highway. This server will become an important tool for cooperation, communication and pedagogical development, notably through interaction with other French-speaking regions and countries.

The Ministry has requested a major effort from those in charge to facilitate ICT integration.

3. Teacher training, innovation and research

ICT is still not widely used in universities and teacher training establishments as pedagogical and didactic tools, therefore recently graduated teachers and teacher trainees are not necessarily well prepared for integrating ICT into teaching practice. The Ministry is currently examining the situation, though already a number of measures have been undertaken:

- universities are collaborating in defining requisite ICT skills, recording best practices in integration projects and disseminating research on these issues. Initial training programmes will be being adjusted in consequence. Results from a dozen or so active research projects relative to ICT integration will shortly be published by FCAR (Fonds de recherche universitaire)[5], a fund set up by the Ministry in collaboration with universities and educational sector partners for the training of researchers and for aid in research. A 3 million dollar budget has been invested in this research[6].
- trainee teachers will do practical training in schools that are successfully integrating ICT, or in regional or supraregional RECIT centres where they have access to appropriate equipment and skills.
- 70 RECIT (which replaced the former 31 CEMIS - centres d'enrichissement en micro-informatique scolaire - in September 2000), i.e. one RECIT per school commission, are dedicated to pedagogical innovation, animation, training and the raising of awareness of teaching staff. A dozen national RECIT coordinate activities for specific sectors (e.g. handicapped learner needs, professional development and adult training) or certain subject areas (e.g. French, maths, arts, humanities). A mediathèque collects all productions realised by RECIT (and the former CEMIS) and ensures presentation and distribution into the school network. Budget $1.8 - $2.3 million per year.

- An annual $300,000 budget is attributed to supporting innovation and research projects, notably on telecommunication projects and models integrating ICT-based teaching/learning in schools[7].

- $400,000 is granted annually to finance new projects (those which have never previously attempted in Canada) that promote the exploration of ICT in teaching/learning environments and which could engender ongoing long-term spin-offs in pre-school, primary and secondary school education[8]. A considerable budget is allocated annually to support the Internet publication of educational contents and offer teachers and students resources and services to support current curricula (pre-school, primary and secondary school)[9].

Further details on these measures can be obtained in the 1999-2000 annual report recently published by the Superior Council of Education and dealing specifically with the integration of ICT in schools[10].
Further information on projects in Quebec: http://vitrine.ntic.org/vitrine/veille/bibtdm.html
For a discussion on the pedagogical basis on which ICT integration in the Quebec educational system is founded, see http://vitrine.ntic.org/vitrine/veille/Textes/BIBrapaille.html

Implementation in practice in Canada

Probably due to the intensive efforts consecrated by the Education Ministry to integrate ICT in primary and secondary schools and consequently the high standards set, several schools contacted in Canada were hesitant about filling out the questionnaire because they consider themselves neither particularly successful nor very innovative in their approach. The first findings apparent from the two questionnaires returned (one from Alberta, the other from Quebec) show that, although the initiative to promote ICT integration is taken both at the school and ministry level, schools draw heavily on the assistance offered at the above-mentioned web-sites, Schoolnet[11] and the School Administrators' Technology Resource (SATIT/RITAS)[12] - an online resource providing Professional Development for school-based administrators across Canada. Education-business partnerships also provide valuable assistance: in Alberta, the Galileo Educational Network provides support for ICT implementation through an intensive classroom-based approach, and the Telus Learning Connection provides Internet-based in-service training, support and mentorship through a cascade model. Hence ICT knowledge is largely supplemented by sources outside schools, though responses also indicate the presence in many schools of an IT agent with technology-based expertise. Team work and regular teacher training sessions (after school hours - early release one day per week for this purpose - and during preparation periods), workshops, professional days, mentoring, one-on-one assistance, but also student mentorship, are underlined as major contributing factors to successful implementation. Decisions on professional development are made by the staff as a whole, and in Alberta each school has its own PD fund to provide extra support. Classroom computer-based training and on-line courses are also available, and teachers can take external computer courses at reduced cost.

Curriculum and assessment

In both schools (one primary and the other a junior high) ICT is used as a tool across the curriculum. The progressive adoption of a cross-disciplinary approach to infuse ICT into core programs of study at a national level is one strategy that is being applied: first Language Arts and Social Studies were integrated into a Humanities program, and recently new study programs with ICT components were introduced in Mathematics and Science. New assessment methods are also being introduced progressively, with current focus on electronic portfolios as a means of developing more comprehensive assessment strategies. This is indicated as a key issue for research both by schools and educational authorities.

Human resources

Many opportunities are provided for peer collaboration between teachers both within and outside of the school through specialist teacher councils, conferences, staff meetings and common preparation periods. Most teachers have their own personal computers and Internet Service Providers, but also have access to the Board of Education Network and to a web-based version of Microsoft Exchange Server.
One key factor contributing to successful implementation is a high level of parent support - an important element also cited by other schools responding to the questionnaire. This is promoted both through close links between school and families, and because awareness is constantly being raised through the efforts of the ministry and the media to the importance of ICT in education.

In response to the final section of our questionnaire analysing the ICT-competent teacher profile, both schools cite "early adapters and risk-takers available to "grab" information efficiently, teachers with a broader variety of teaching strategies, adhering to a constructivist philosophy of education, and able to create their own teaching material". They point out the need to identify and support "champions" as a means of leading other staff to experiment with new teaching and learning modes. Time rates as the most important overall factor to integration: time for training, time for PD, time for collaboration. The

H.D. Cartwright School in Alberta completed the questionnaire with a list of elements that are facilitating its ICT integration:

- good network and computer infrastructure
- supportive administration
- commitment to a middle school philosophy highly compatible with ICT integration
- professional staff that is willing to move forward,
- core of knowledgeable lead teachers
- solid core of technologically literate students who make up the Tech Club and maintain the web site.

AUSTRALIA

General ICT implementation guidelines are drawn up by the Australian Commonwealth government, but it is up to the six states to determine their own integration strategies. ICT literacy is considered as being *inherent to overall educational objectives, the underlying philosophy being that today's students must expect to work and live in environments requiring competence in computer use and in convergent digital technology. As living and working environments will also increasingly require citizens to accept innovation and adapt skills and understanding to change, it is considered that information skills need to be conceptualised broadly, focusing on learning how to learn, rather than the acquisition of specific technical skills that will need to be frequently unlearned. Students' skills in using information technology are considered inseparable from their analytical abilities and their capacity for creativity, teamwork, problem-solving and communication skills*. Australian school systems are therefore subscribing to an integration philosophy involving the infusion of computers as a tool across the curriculum, with strategies directed towards the above goals, but also the more traditional ones such as:

- improving students' understanding, assimilation and creation of new knowledge through the presentation of information in fresh and relevant ways;
- adapting to students with different learning styles or special needs;
- motivating and stimulating learners, thereby reducing the risk of failure at school;
- improving monitoring, guidance and assessment of individual students' progress.

ICT implementation strategies focus on *organisational* as well as *ethical* aspects, with "technology and society" studies, and in the later grades media education, playing an important role in the curriculum. National guidelines underline four parameters which determine the success of ICT integration:

- the definition of a clear policy for implementing ICT,
- professional development,
- careful planning to overcome barriers that may impede equitable integration of information technology and thereby compromise the opportunity for all students to acquire information technology skills,
- benchmarking (i.e. continuous search for best practices that will lead to superior performance): it is suggested that performance indicators should be employed at 4 different levels - classroom, programme, school and system - for the use of higher education institutions, government, funding bodies, students, teachers, teacher unions and the public at large.

It is recommended that ICT implementation strategies be developed at three key levels:

1. The school

All schools in Australia are required to draw up their own ICT plan, incorporating targets set by the local education authority, but also based on targets of their own. It is suggested that all available resources in the school be linked at a "whole school" level, as this appears to be the key to integrated planning and ensures more successful ICT integration in the school, the classroom, across the curriculum and in the school community. ICT is to be integrated into the curriculum flexibly, addressing the competencies that all students should acquire through horizontally and vertically integrated approaches to curriculum planning. Schools are recommended to explore innovative ways of funding the expansion of IT infrastructure (use of corporate partnerships are central to ICT infrastructure strategies in most states), however, over-emphasis on the amount of equipment in schools (e.g. student-to-computer ratios) should be avoided.

2. **Teachers**

Teachers play a key role both in drawing up well-articulated school-level ICT policy and in the implementation process. But before they are ready to invest in this process by modifying classroom practices, they must see the relevance of using ICT in the learning process in terms of clear links to school curricula and intended student outcomes. Teachers' beliefs have the greatest influence on teaching practice, hence the need to raise awareness to the major changes that have occurred in schooling patterns and the philosophy underlying this evolution. Awareness must also be raised as to the use of ICT in relation to individual learning styles, differences and attitudes.

Level of teacher use of ICT in school is directly linked to:

- level of resourcing and planning in the school,
- access to computers (obsolescence and unsuitable location of equipment have been pinpointed as major barriers to ICT integration),
- availability of software, connectivity,
- degree of support provided for in-service education, including time release
- opportunity for professional recognition and promotion.

It also depends on the amount of time teachers are given to experiment with technology and plan lessons using new methods that incorporate technology Above all, full integration depends on developing an effective mechanism for assessing and reporting ICT outcomes across all curriculum areas.

3. **Teacher training**

If the desired ICT integration outcomes are to be achieved, training institutions will need to support both trainee teachers and those already in the classroom by providing a suitable environment to use computers, not only for instructional purposes but also to develop confidence in using hardware and software. All teachers need the opportunity to become competent in using "higher" computer skills in their own learning (i.e. analysing material downloaded from Internet, creating home pages for schools, facilitating communication between students…) before attempting to use them in their teaching. Lack of knowledge or understanding of best curricular uses of technology (what software to use, how to integrate it into the curriculum and how to organise classroom activities) is the major barrier to integration and can only be overcome by sufficient training, support and models of best practice. Education systems must therefore:

- establish a regime in which ICT skills are expected and rewarded;
- provide professional training activities related to the curriculum and to examination requirements;
- assist teachers to practise computer skills at home and in their own time;
- give teachers access to support staff who are not only technically competent, but who also realise the implications for classroom applications.

Most Australian states are using private providers to arrange in-service education for teachers.
The teachers themselves usually opt for school-based ICT training after teaching hours on school days, and prefer short courses and workshops rather than extended modules of study.

Integration assessment

Progress towards ICT integration goals may be evaluated in terms of the extent to which all students are:

- Developing skills in using information and computer-based technologies;
- Expressing ideas and communicating with others using computer-based technologies;
- Demonstrating discrimination in the use of computer-based technologies;
- Developing the confidence to explore, adapt and shape technological understanding and skills to future challenges.

On the basis of these and other criteria, a survey carried out Australia-wide in 1998 by the Commonwealth Department of Education, Training and Youth Affairs reveals the following:

- nearly all students have more than half of what is considered basic skills core to the operation of computers (see Annex). Nearly 67% have all of them. The majority of students developed these basic skills at home. Teachers' basic skills are almost equivalent to those of students. In advanced skills (multimedia creation, using video music and sound clips, creating and creating web sites or home pages, see Annex) students are more capable than teachers. Informational use appears to increase with students' ages, creative uses decline. Girls, and students in rural, isolated and low-income areas have less advanced skills than other students, students also tend to learn these skills at home.
- 25% to over 50% of teachers lack some skills necessary to use or teach a range of computer applications. Young teachers enter the teaching profession with more advanced skills, while those with slightly more experience are acquiring them rapidly. Those lacking sufficient ICT skills tend to be over 50, female, and primary school teachers. Many teachers do not find the training available to them adequate to their needs.
- 71% of schools surveyed report a student-to-computer ratio of 15:1, with 40% reporting a ratio of 10:1. Where student-to-computer ratio is advantageous, students are more confident about their own basic and advanced skills, more satisfied with resources provided and more likely to enjoy using computers at school. The majority of schools depend on a single teacher to coordinate information technology provision, large schools call on a wider range of personnel including network managers and technicians.
- Sixty per cent of principals reported that information technology was one of the three highest budget priorities for their schools. The overall highest priority is given to hardware and software for students, with lesser commitments to staff development, technology support, communications and networks and hardware, and software for staff, in that order. Where information technology is a high budget priority, principals are more likely to perceive support services as adequate and to be confident that the staff is well-trained and equipped to adapt to the challenges of ICT.
- More than two thirds of schools have developed a school policy on ICT. There are consistent links between the existence of a school policy on ICT and the priority given, at a school level, to resourcing, networking, technical support and professional development, and to integrating ICT across the curriculum. Most policies cover both immediate and long-term objectives, including those relating to security, regulating access to obscene and restricted material, copyright, health and safety and plagiarism.
- there is a divide between IT "haves" and "have nots", it is therefore most important that equity outcomes of current policy be assessed.

Implementation in practice in Australia

The Australian school participating in the survey is the John Paul College, an independent ecumenical college located in Queensland and catering to grades K-1 to K-12. This college was selected not only because of its very successful ICT implementation policy, but also because it is fairly representative of the Australian independent school system. Several factors render this school particularly interesting. Firstly, ICT is critical to its educational vision: "[…] *a commitment to developmental learning and teaching where the Student is at the centre of the learning process; learning must be contemporary and relevant; how to learn is more important that what to learn, learning is a life-long process and should be fun.* Within this vision, the College focus is *to provide a media rich learning environment, where the use of powerful technologies is embedded into student's everyday experiences… If a person is to participate fully in, contribute to, and influence the future of his or her world, he or she must be empowered with the capacity to develop and communicate ideas through the media of his or her time."* Hence ICT is explicitly and implicitly embedded across the curriculum from K1 through to K-12.

Technological infrastructure

The second aspect of particular interest is the college's ICT infrastructure. It has set up its own Intranet, and all resources are on-line. Video conferencing is integrated as part of current teaching practice. All staff, and students from Year 5 onwards, have their own Notebook[13] with Radio access from school and home to personal web spaces, e-mail, work space, Internet, CD-ROM and applications on their Notebook. The college considers the use of radio as a key innovation that has completely changed the nature of teaching and learning. In 2001 current pedagogical dimensions will be considerably enriched through the installation of technology curriculum Knownet, an Australian version from Knowledge Network, a South African company. This will provide a creative framework for professional development and support for staff, allowing for increased sophistication in the application of skills and depth in the layered use of the software packages. A partnership with Microsoft provides both technological expertise and impetus for many innovations.

Although John Paul College sums up State and National-level integration strategies as a lot of hype and a little intermittent funding, its strategies do reflect national recommendations in several ways. Firstly, resources are planned and linked at the whole school level, centrally located and disseminated through the school via an intranet. Secondly, a teacher-training regime in which ICT skills are expected and rewarded is also prescribed in national policy. At John Paul College, as part of the salary award, all teachers are required to attend fortnightly professional development sessions in Technology, have a current notebook computer, participate in learning area professional development and whole school professional development. As an added incentive, staff receive full external certification such as the ICDL and MOUS. Staff members are expected to use their "higher" ICT skills in creating online content, assessing students' work and collaborating with students, parents and colleagues.

The college is quick to point out that working in an online environment provides dramatic changes to teaching, learning, pedagogy and assessment. Existential questions are posed as to the very role and responsibilities of a teacher. Parents often have difficulties in understanding the role of ICT and video conferencing as being pedagogically sound. For this reason, the tri-partisan role of the college, students and their families is strongly emphasised in the learning venture. In 2001, the college is launching its own information community web portal for students, teachers and families. This will provide an e-mail account and web-site for each family in addition to student and staff accounts, advertising for family businesses, a radio station run by students, web streaming of cultural and sporting activities, and professional development and training for staff, students, parents and other associates of the college.

Curriculum and assessment

The whole curriculum has technology embedded through it. Learning is active, student-centred. The curriculum is selected and sequenced to meet the needs and stage of development of individual students. Cross-curricular projects are encouraged, reflecting real life issues and tasks. Student web sites are used for presentation and teacher assessment. Web-enabled assessment automatically provides feedback to staff and the students. Teachers are expected to create on-line content, and a central repository of information allows them to search the college web base for content relevant to the lesson plan they are creating. The chat room is available for all classes/subjects. Learning content in Year 8 and 9 is now online, allowing for individualised learning anywhere, anytime. In Term 2, 2001, on-line assessments will be set up for all on-line content using Microsoft Encarta Class Server, a new product from Microsoft that is presently undergoing "trialing".

Teacher training

A school wide approach is adopted towards teacher training, and policy is driven by the Headmaster, the Information and Learning Technology Director, pedagogical directors and Information and technology coordinators. Extensive programmes have been conducted in both pedagogical and technological training. These include widely diverse topics ranging from applications and internet links to creating online learning resources and pedagogical learning in a web-enabled world. Professional Development takes place before and after school once a fortnight for one or two hours, with both formative and summative assessments being carried out on training content. As students are to be certified with technology skills, teachers must be certified with appropriate skills to facilitate this process. In October 2000, the PD changed to engage in the Knownet Curriculum. For a more comprehensive view of this, see www.knowledgenetwork.co.za. Teachers seem ready to invest in training only if this is seen as an integral part of the salary award, is contextual, and is directly applicable to their own learning or their classroom practice. The latest training programs integrated through the KnowNet are systemised, credentialled and certified by both external agencies and internal assessment.

Outside of PD sessions and regular teacher meetings, staff collaboration is encouraged through access to the Intranet and workspaces from home. The college is currently working with Telstra, the major Australian telephone provider, to set up a new VPN service free to all staff and students. The technological infrastructure provides for constant feedback by staff and parents, and programmes being continually modified to take into account the input of both parties.

The younger staff appears to adapt more easily to ICT integration in teaching practice. The worst performers from this point of view are year 11/12 teachers and mathematics teachers who are constrained by time and flexibility due to System wide State external assessments and curriculum. John Paul College provides the following list of criteria as being inherent to a successful ICT integration:

- in terms of human resources and professional development, providing comprehensive training that includes
  - Certification
  - Contextual
  - Various methods of delivery - learning styles, online, hand-on, one on one, small groups etc
  - Compulsory
  - PD is an essential component of school policy and direction owned by all
  - PD learnt is directly transferable to teaching
- in terms of technology:
  - Connectivity, portability, battery life and technical support

FINLAND

Finland is considered to be a European leader in implementing ICT in education. 90% of primary schools and 95% of secondary schools are connected to Internet - the highest level in all of Europe[14]. In 1995 the Finnish Ministry of Education launched its first "information strategy" (annual budget €45.5 million), aimed at steering the development of the national information society in the field of ICT and research. This was followed up in Spring 1999 with the launching of a new information strategy for the period 2000-2004 (annual budget €50.5 million). As a means of implementing the visions outlined in its second strategy, the Ministry is enlisting the resources of a number of educational partners, including the autonomous municipalities which run a vast majority of primary and secondary education establishments. Further to the example given by Nokia, it also calls on the business sector to play an increasing role. Finland further intends to take advantage of domestic and EU instruments for ICT implementation in schools. Special Focus is being placed on content production, notably in the crucial area of learning materials.

The stated vision underlying the information strategy: *In today's Information Society in which the demarcation between the learning environments at home, school and workplace is disappearing, increasing attention must be focused on net-based learning and school/work relations in teaching. This calls for new, more varied methods in the planning, implementation and evaluation of teaching. At the same time, citizenship skills must meet the needs of a networking, constantly changing and internationalising way of life. These skills include technical, communication and consumer skills, and the capacity to influence Information Society policy. As more and more tracks are becoming available in lifelong learning, it is also increasingly important to guide pupils to develop the ability to "learn to learn". In terms of positive information society development, this necessitates not only intensified use of ICT, but also the development of an operational culture in educational institutions.*

Three main action lines are being taken:
- training of teaching personnel and development of an information strategy
- creation of a multidisciplinary Research and Development network as a means of identifying and disseminating new, widely applicable practices, but also for educating and training the information industry and digital communication professionals (growing concern about workforce shortages in ICT industry)
- creation of a virtual school as a means of establishing adapted learning environments based on new information and communication technologies.

One major aim in Finland is to launch a multidisciplinary graduate school in learning environment research which will primarily include educational science, psychology, media sciences, applied linguistics, computer sciences and information research.

1. Teaching personnel and the information strategy

All teacher education units should devise an information strategy by 2001, and all educational establishments by 2002. The aim is that a large number of teachers will have at least basic ICT skills. In teachers' initial and further education, the emphasis is on the role of the whole school community in the development of educational ICT. In-service education should not only upgrade the individual teacher's professional skills, but should also serve the whole work community.

Teacher training will be provided by universities and polytechnics in collaboration with the National Board of Education, and is planned as a three-step process:

- Every teacher must acquire knowledge about common uses of computer, mastery of basic applications including email and Internet, and an understanding of the principles of the educational uses of ICT.
- At least half of the personnel working in education should master skills for using ICT for educational purposes i.e. versatile use of email, the www environment and groupware: generic tools, pedagogical applications and digital material in the subject taught, and principles of digital learning material production. They should also be capable of following hardware and software developments, and have an awareness of the social problems and challenges involved in ICT.
- About 10% of teachers should master specialised knowledge: content-specific and professional applications, the production of digital learning materials, institutional information management and the ability to assist, support and train colleagues, develop the school community and act as part of an expert network.

2. Multidisciplinary R & D network

This is intended to cater to the needs of virtual universities and schools, as well as the whole information strategy. It will support the development of net-based study arrangements and develop new learning environments of high pedagogic quality. More particularly, it will:

- Forecast developments at home and abroad and keep Finnish research at top world level
- Offer research-based views on how network schools should be developed
- Make proposals for development of mainstream school forms by means of new technologies
- Promote research interaction between partners involved in the project and with international centres in the field
- Help commercialise digital learning materials and use them in teaching
- Assist in the development of alternative evaluation models and in research-based monitoring of the information strategy.

3. The Virtual School

This is aimed at providing anywhere, anytime access to study opportunities of a high pedagogical quality for students of all ages via the virtual network. But it is also intended as a means of:

- developing and diversifying cooperation between educational institutions and society, notably the world of work
- creating development networks which produce and supply educational and advisory services and materials, including international services
- studying and developing the principal practices of relevant pedagogy
- helping schools develop their activities towards a virtual school
- identifying and solving technical, pedagogical, social and administrative problems relating to new forms of study and learning
- providing a forum for the development of teachers' and students' ICT skills

The virtual school has already facilitated important changes in certain upper secondary schools[15]. In the aim of encouraging the development of independent learning strategies and increasing personal responsibility for education, schools in several areas in Finland now allow students to follow a module-based cursus not tied to year classes. In this way students benefit from a much broader choice of subjects, sometimes selecting modules from local business training programmes, other educational institutions or disseminated through the virtual school net. Only about 60% - 65% of the curriculum remains compulsory in such schools. Obviously, assessment methods have been largely modified to accommodate to the greater flexibility, with the emphasis on self-assessment but also including verbal reports, assessment interviews and portfolio assessment.

In the framework of the virtual school project, schools are supported in hardware and software acquisitions on the condition that they undertake strategic planning, build supportive service and develop learning materials.

Implementation strategies in practice

The questionnaire was filled out by just one school in Finland, the Tehtaapuiston Ylasteen Koulu (junior high school). It seems that national policy has a major impact on school-level policy, with few implementation decisions being left to the school. National policy stipulates both the aims of and the resources to be implemented for ICT integration, though the provision of the latter is up to the school and/or the local authority. This school considers that it is achieving the educational objectives underpinning ICT integration, as "All students have quite good knowledge of ICT, and the ability to use e-mail, easily find information from www pages, produce texts and tables and make animations. They can use network programs, email, and some are able to make their own home pages, modify photos and do some basic programming."

Curriculum

A cross-curricular approach (as suggested by national policy) has been adopted and ICT integrated into almost all subjects, with teachers using their own discretion as to when ICT can really contribute to learning content and processes. In order to find the extra time necessary to focus efforts on ICT implementation, other less important curriculum and classroom issues have been put aside for the moment. Teachers have benefited from training initiatives organised by local authorities to assist them in introducing curriculum changes. Since the introduction of ICT, the major pedagogical change has been a shift towards developing more active learning styles, with teaching more child-centred.

Technological Infrastructure

Most classes at this level of education in Finland comprise about 22 students. Each class is equipped with between 1 and 3 computers. However, computers are also located in the library, and in two computer laboratories each containing about 20 computers. Classes move into computer laboratories whenever necessary. The head teacher who filled out the questionnaire states difficulties in attaining the national aim of 1 computer per 6 students. Other available learning resources include TV, overhead projectors and video-conferencing equipment. IT applications most widely used are www pages and ready-made-programs.

Teacher training

Teachers are expected to acquire competence in all available applications (Word, Excel, PowerPoint, PhotoShop, creation of www pages, Internet, email…), through in-school courses either during or after school. They can also apply for permission to take courses out of school. Most teachers have their own computers from which they can access their school email address. This greatly facilitates teacher-parent exchanges, and has substantially improved the hierarchical relationships between home and school. The teachers most competent in using ICT for pedagogical purposes appear to be the younger staff members who are keen on introducing new methods. Peer learning figures largely as a means of human resource development, through staff discussion focusing on teaching methods and how best to activate children.

ISRAEL

Israel is unique terms of ICT implementation, as it is one of the only countries to be doted with a "Science and Technology" division within the education ministry long before ICT integration became a major educational objective. This service was originally created to steer the young nation towards industrial autonomy back in the sixties but has, since the late seventies/early eighties, taken over the responsibility of ICT integration in primary, secondary and university education. This accounts for the long-standing partnership that exists between education and business/industry, which represents a major source of expertise and financing in setting up the high technology infrastructure required for successful ICT integration. It also led to the development of a flexible secondary school curriculum broadly infused with technology, which has today somewhat facilitated ICT implementation[16].

Philosophy underlying ICT implementation strategies

The focus of learning has shifted from the acquisition of knowledge to the development of students' ability to acquire and process knowledge, to draw conclusions from that knowledge and to produce the original thoughts, ideas and capabilities that will be indispensable in the new world. In particular, ICT implementation should aim at:

- Equipping students with skills and knowledge in the fields of information and communication technologies
- Making use of ICT to provide students access to the best of the world's cultural assets
- Bringing to students a rich learning environment that will allow them to search for and retrieve information through different media, to organise it and to independently build their own knowledge base.

National ICT implementation is for the most part financed by the Ministry of Education, municipal authorities and the National Lottery. A first "five-year" plan launched in 1994, was aimed at and succeeded in computerising approximately half of Israel's educational institutions. Evaluation and research accompanied all stages of the project's implementation. The information gathered and the research analysis from the first plan formed the basis for constructing the second stage[17]. Upon the recommendations made on these findings, the new plan focuses on developing:

- new curricula in all subjects, with the assistance of the best academic and pedagogical resources
- adapted curricula for teacher training and in-service training for teachers
- new evaluation methods. As learning in the ICT environment is mostly "portfolio style", the main method for evaluating students is assessment of the learning process. This method is being comparatively tested in certain schools by conducting two study-skill assessments at a one-year interval - the first before the school joined the computerisation programme and ICT was introduced, and the second after implementation. The second test results are then compared to the teacher's evaluation of the student's portfolio. Results from this comparative study are not yet available.
- a technological infrastructure suitable for providing various systems of educational services via broadband communications based on existing communication infrastructures and futuristic technologies: shortly all schools in Israel will have access to three communication networks - local (inter-school LAN or Intranet), regional and national.

Further to these objectives, the Ministry of Education recently issued a bid for supplying Internet services to school. The service supplier has to provide all schools with the communication tools necessary for e-learning: forums, e-workgroups and synchronous learning activities.

Implementation strategies in practice

The four Israeli schools that completed the questionnaire illustrate the broad diversity that exists in implementation strategies, even in a comparatively small country. These shall be examined individually. The first comes from the Shaar Hanegev school, a K-1 to K-12 school located on the same campus as a tertiary level college. At Shaar Hanegev, although the ministry initiative acted as a trigger to launch the implementation plan, it was the school principal's decision to give high priority to ICT integration that was decisive in the overall success of the project. The actual strategies of the declared Ministery policy had little influence beyond defining the mode of fund allocation (i.e. specific proportion of budget to be spent on software and hardware, other grants that can be used only for in-service training, etc.). Local headmaster are fairly limited in their degree of freedom in regards to budget allocation decisions.

Physical and Technological Infrastructure

In primary school, there are 2 PCs in each class, and 1 printer per 3 classes. One computer lab equipped with 12 PCs and special resources such as scanner, printers, video camera, etc. for basic skills learning and one media center. All PCs are networked and provide Internet access. In high school (age 12-18), subject rooms are typically equiped with 1 PC per 6 students (math, EFT, geography, judaism/bible, social studies). Special computer labs are available for technology, computer science and natural science. Once again, all PCs are networked and offer Internet access. The high school is also doted with a media center similar to that of the primary school. The overall average student to computer ratio stands at about 10:1. The teacher's room is equipped with 4PCs.

Objectives, Curriculum changes

The educational objective underpinning ICT integration in this school is *to implement to the greatest degree possible an educational strategy based on Thematic, Collaborative and Information-based learning.* In light of this objective, a cross-curricular approach is being progressively adopted, with a pilot now running in social studies based on integrative work. Whilst ICT implementation has been a trigger to develop such programmes, the use of ICT currently is not very wide. In each subject area where the use of ICT demands the development of new skills (e.g. in language studies for the use of word processing, in Biology for the use of spreadsheets, etc.), time allotments are extended accordingly. But when the use of ICT is inherent to the subject matter, no extra time allocation is given, for example, using a function analyzer in mathemathics or a drill program in EFT.

Teacher training

Despite the availability of national teacher training courses, the school chose to prepare its own staff for ICT integration with the help of independent consultants. In most Israeli schools, this is not the case, and usually a national mechanism of mentorship is used. From the very outset of Shaar Hanegev's ICT integration programme, an extensive in service training program was offered to teachers during vacation times. Attendance (voluntary) was high. Over the first 2 years basic skills were introduced, e.g. how to operate a computer and use of basic software such as word processors. In the third and fourth year, modular workshops were conducted on various aspects, including Internet and related items. Now workshops focus on subject areas, are task-oriented, and aimed at developing learning materials. Training courses also take place all year long, conducted by a support team of experienced teachers that help colleagues prepare material and master basic skills. A third form of training takes place in each class, with certain pupils helping the teacher in operational tasks. More and more teachers are accepting the idea that they can learn from their students in some areas. There are increasing opportunities in the classroom for collaboration to develop between teacher and students, for each side helps the other in the learning process.

Probably the major incentive for teachers to participate in teacher training is the implicit message from the school direction that teachers who invest in these activities are more valued and have a better chance of getting promoted. About 20 % of teachers are very enthusiastic, 50% participate because of the school climate and the attitude of the direction. 15 % are not ready to take part in the integration programme because of a lack of capability, motivation, or for personal reasons. Some 15 % simply make a conscious decision not to use ICT, because they cannot master the skills, don't think they are important or because ICT does not fit in with their teaching style (some of these are, incidentally, excellent teachers).

Pedagogical approaches

ICT integration was, from the beginning, viewed as the means of achieving a desired pedagogical approach. Class settings and the deployment of ICT permitted this pedagogigal approach to be implemented. The investments made and the directives formulated by the direction of the school conveyed the desired message to teachers. To facilitate implementation, two ICT managers with a high level of technical expertise but less pedagogical experience collaborate closely with pedagogical leaders elected in each subject matter and given an allotment of non-teachings hours each week. As a result, there appears to have been a shift of focus from subject to process, so in areas where ICT is more used, teachers give more attention to the learning process and skills than to the particular content being studied.

The relationship between teachers/parents/pupils/hierarchy has been considerably modified by the integration of ICT, mainly through the availability of easily accessible information on the school web site (administrative and learning activities) which permits more parent involvment. Most teachers have PCs at home with web access to the school site. They can collaborate with each other both within and outside of school by means of the school site, which includes e-mail and mail list facilities.

Criteria for successful integration

When questioned about the profile of ICT competent teachers, the Shaar Hanegev staff maintain that integration success is more an organizational than a personal variable, since schools with similar teaching population profiles often differ widely in ICT implementation. It is noted, however, that teachers fluent in English have a head start over others. The staff has drawn up a list of what it considers to be the technological criteria for successful ICT integration:

- configuration design according to planned use,
- the use of network resources to administrate the system centrally, so that station configuration can be easily set up,
- allocation of funds for maintenance and upgrade. The ICT managers point out that many schools have made the error of investing heavily in purchasing hardware, but after less than 3 years can no longer use most of it because of lack of means to maintain the technical equipment, and lastly,
- "It seems critical that teachers have an on-site support team with whom they have a constant dialog. The support team must fully understand the teacher's needs, the curriculum, be technologically capable of offering teachers ICT tools for fulfilling their needs and be supportive enough to help them in implementing the tools in the classroom. We think that this might be the single most important factor for successful ICT implementation, once the necessary condition of funding for hardware/software deployment is met."

Hagalil Primary School

The computerisation process is seen in this school as an inevitable development of the modern school system, and national integration guidelines have played an important role. National level assistance has included:

- help from advisors in the planning of the layout of computers,
- funding for the purchase of computers and peripheral technology (printers, scanners, software…)
- "integrator" organisations that provide a holistic service to schools at the level of hardware and software,
- advice and counselling in terms of human resources, in-service training course, intensive training of the ICT coordinator,
- the intensive aid of a counsellor within the school is also available, but this school did not use it.

The school has set up numerous task-based work groups, one of them responsible for the progress of ICT integration. Five of the full staff meetings per year are run by this task group, where they address issues relevant to school needs and based upon the goals and achievements of each school year. The school also has two pedagogical advisors who work with and train teachers in the pedagogic integration of computers in the learning process. The principal makes the decisions on personal development, but all teachers partake in these training courses within the school after school hours. Those who need individual support or training can meet with the ICT integration coordinator on a one-to-one basis.

Coordinators in the various subject areas partake in courses outside of school which integrate ICT into the subject matter. Teachers who show incentive and initiative in ICT integration are awarded with extra teaching hours, but most simply consider their training as part of the school culture. All teachers have computers and internet access from home, and receive inter-staff information via email. Teachers who enjoy challenges, master application tools and know how to integrate them differentially are the most capable of adapting their curriculum and teaching process to integrate ICT-based methods. However, this can only be achieved by long hours of training and assistance at the personal and group level. Aid must be based on the individual needs of teachers.

Integration objectives and level of attainment

National policy underlines the importance of developing computer literate pupils able to use the computer as a tool in the learning process. More particularly, this school states as its objective *"to educate school-leavers capable of adapting and integrating in a changing world of technology and information. The pupil should be capable of flexible thinking and a user of advanced information technologies."* As the school is situated in an average to low socio-economic neighbourhood where most of the children do not have access to computers at home, one of its major aims is to narrow the growing digital divide between these children and those of other neighbourhoods. It is considered that approximately 80% of the overall objectives have been achieved. Most children use the computer in an intelligent manner, to access relevant information from the Internet for projects using exploratory learning methods, to present digital portfolios and to reflect on their thinking processes and achievements. The computer room is used to full capacity, mostly for finding and documenting information and for problem solving situations.

Technological infrastructure

Each of the twelve "standard" classrooms have two computers (486) each, the computer laboratory is equipped with 28 terminals, the science and math room with two computer and one computer respectively, two computers are located in the library and another one in the teachers' room. This shows that, although the ideal pupil to computer ratio is cited by the school as being 2:1, the number of computers available is not the most important factor in successful integration. This seems more to depend on connectivity, accessibility, availability of accessories (paper, ink, etc.), continual upgrading

of equipment and immediate integration and use of new technologies as soon as they have been purchased.

Curriculum content

Hagalil Primary had already adopted a cross-curricular approach before ICT integration began. The prevailing method of learning is constructivist, where pupil knowledge is developed on the basis of previous knowledge and learning is based on the subject matter and knowledge presented by the pupils. Each subject is learnt through basic concepts and thinking processes in order to extend the child's learning ability, e.g. literature may be the starting point for examining dilemmas. Time allotment per subject generally follows a set timetable and division of hours for use of the computer room, however certain hours are flexible. The timetable is also adjusted according to the particular stage and needs of the learning process of given teachers, pupils and subjects. ICT integration has brought about one major organisational change: traditional division of school hours during the day has been changed from 45 to 90 minutes to allow teachers and pupils a more in-depth examination and learning experience. The computer is only used as a tool when and where its applications add value to the learning process.
Two types of changes have been noted in curriculum content. Information gathering activities have become more frequent and accurate through use of digital tools to develop surveys and questionnaires. Secondly, certain subjects or topics (e.g. daily news and current events) not previously addressed have become an integral part of what is learnt at school, because digital tools have brought added authenticity.

Outcomes

The teaching team today is developing a greater tendency to work and think together as a group. Teacher/pupil and peer collaboration for both have increased. Successful ICT integration can only be achieved if the necessary time is allocated to training and development, and if the school system remains sufficiently flexible.

Harishonim Secondary School

The questionnaire from this school was filled out by the ICT coordinator, who also considers that the national integration policy set the stage for the direction and aims of the integration of computerization in the school. Most integration decisions, however, come from the school principal, vice-principal, the technician, and the ICT integration coordinator. Harishonim was computerized over a two year period, with an allocation of 140 computers. At each stage of computerization, a sum of money was allocated to the purchasing of software and applications. Advice and assistance in human resource development was provided by the regional computer training center, which also provides courses on the integration of ICT in various subject areas. Other training courses to direct the teachers in their use of ICT in the classroom based upon the education policy for ICT integration were provided or funded by the national ICT integration programme. The ICT coordinator received training in a course organized and run on the national level, and aimed at training facilitators for schools integrating ICT in their learning environment.

The educational objectives underpinning ICT integration at Harishonim Secondary was *to ensure that, upon leaving school, all students are computer literate and able to make intelligent use of computerized information resources and tools.* By the time they graduate, pupils have spent a large number of hours using computers in their studies.

Teacher training

The training of teachers has been a long and ongoing process which began before the computers arrived at the school. In all, the school received many ICT teacher training courses, aimed at achieving three major goals:

- Basic computer skills for the teachers – Office and Internet
- The integration of ICT in the teaching/learning process (for the more computer literate teachers)
- Development of a group of leading staff members to develop ICT-integrated curricula.

Special time slots were allocated for in-service teacher training, although teachers also attended after-hour training courses. In-house courses were facilitated by the school computer coordinator. The teachers chosen to develop learning tools for the integration of ICT in the classroom received intensive training and met with an ICT integration counselor on a one-to-one basis during regular work hours. Most teachers participated in in-service training, whilst others attended courses during their sabbatical break.

The incentives used to encourage teachers to invest in ICT integration are mainly based on staff acknowledgement. The results of the work done by teachers in the various fields of ICT are presented to the rest of the staff, the school site is used to present lessons developed by teachers, and teaching units are partially developed during work hours. Groups of teachers (grouped by subject matter) are given the opportunity to participate in courses at the local Center for Integration of Computers in Education (financed by the national ICT integration program and the local municipal government).

Teachers having difficulties discovering what to do with computers in their subject areas are allocated hours for teacher training, coordinated by the ICT integration coordinator, though this obstacle is generally overcome by promoting the participation of all teachers in courses within the school and out of the school. Gradually more and more teachers are developing the basic computer skills and an understanding of integration of the computer in the classroom, though not all the teachers are willing to develop in this area.

Pedagogical approaches, curriculum content and assessment

The school has adopted a modular approach whereby pupils choose the subjects they want to study. There are very few examples of cross-curricular teaching within subject areas due to the preparation for the mandatory 12th grade external examinations. Time allotment per subject has been modified to some extent in that certain classes are divided into two, with half of the pupils attending a lesson in the computer laboratory whilst the other half attend a lesson with the class or subject teacher.

Pedagogical approaches have considerably changed in that many teachers show interest in integrating ICT in the classroom in an attempt to improve teaching methods and make their lessons more relevant to their pupils and their subject matter. This change began taking place as soon as teachers became aware of the potential of on-line lessons and the use of creating a "pool" of teaching materials on the net. Many subjects now include a variety of teaching methods, including group learning, enquiry methods of learning, and simulations. A large amount of course material has been developed by teachers which integrates the use of ICT and is available to pupils on-line, either in the classroom or from home. This allows pupils to study independently, from home and at their own pace. Preparation for examinations are available on-line for pupils. Before the final 12th grade examinations, they partake in a "marathon" of revising the material learnt through e-learning using satellite and video conferencing. The pupils present questions, which are answered on-line.

Certain teachers have adapted curriculum content so as to integrate the use of ICT in the learning

process. This is particularly noticeable in Science (chemistry, biology, physics), English, government studies, Physical Education (physiology), bible studies. New subjects such as information science and digital media (on-line newspaper) have developed based on the use of ICT. But the main changes are noted by the English language teachers. Some of these teachers utilize the computer room to teach part of the syllabus (in the past, something that was more prevalent amongst the teachers of pupils with special needs). "Citizenship" (government studies) teachers have developed a special curriculum which is part of a project using alternative assessment to replace regular final examinations. They have developed learning units which integrate the use of internet forums and Internet sites dealing with human rights, citizenship and democracy, and the right of free speech. The methods used present an added value to the subject.

In other subject areas such as biology, physics and astronomy the computer is essential to the subject matter and to the methods of learning the material. The use of simulations in these subjects could not exist without the computer. ICT use in teaching English has greatly improved the level of understanding and expression. ICT is also essential to both to subject matter and method in teaching video and digital editing. Alongside the modification of curriculum content, assessment methods have evolved, though not solely due to the integration of ICT. Rather, the school has undergone changes which have coincided with the use of ICT. Computers and ICT are an integral part of the assessment process in this school.

Technological Infrastructure

Computers are located in the library, science laboratories, (biology, physics, chemistry), media studies room, staff room, two teacher training rooms and the administration centre. There are also 4 computer rooms, each with 20 computers. Computer configurations are mainly Pentium 133 – 233 with 32 Mb memory, windows 95 and MS Office 97. The most widely used applications are Ms Word, MS Excel, and the Internet, as well as content based programs for certain subjects (essay writing) and simulations (physics).

The computer infrastructure has modified classroom organisation, e.g. in the science laboratories each group has a computer with internet connection on their table and the students partake in group work. In the computer room, each pupil has access to a computer. The class is divided into groups, so that only half the class is in the computer room while the other half is in a different lesson. In this case, the use of the computer room has changed the organization of lessons in that the student:teacher ratio is halved

Technological criteria for successful ICT integration:

- A sufficient number of computer for students
- Fast speed Internet connection
- Continual upgrading of hardware and software
- Sufficient quality accessories: printer, scanner, digital camera, CD writer

Outcomes

Teachers are beginning to learn from their pupils without being afraid of losing face. At first, teachers had difficulty with the feeling that they were not the sole source of information and knowledge, not the only specialist in the field. The role of the teacher is changing, and the connection between pupils and teachers improve and strengthen when the pupils aid the teachers. It is important to continue to strengthen the view amongst teachers that in the age of information, they are not the sole bearers of information and knowledge. Teachers and pupils communication has improved, both through email and on-line discussion groups.

Staff are given more opportunities to collaborate with each other within and outside of school through staff meetings and training courses, divided by subject matter or by the grade they teach. During school hours and after hours teachers meet to develop ICT integrated learning materials. Through team work they develop units for the various subject areas. The school internet promotes forums for the "School community".

English teachers and teachers of pupils with special needs appear to be making the most use of new teaching/learning opportunities. The most ICT-competent teachers are those who have developed skills and competency in the basic computer tools, and are interested in investing in their professional field. They are also:

- Teachers who show initiative
- Teachers with leadership skills, able to work collaboratively
- Teachers who are in contact with colleagues from other schools, and receive professional training outside of the school within their field of expertise

All staff members are gradually being encouraged to develop ICT competency through promotion of collaborative work in developing an ICT integrated curriculum, promotion of courses within the school environment, and technical and pedagogical assistance and training for teachers who show initiative.

Four other criteria are listed by this school as contributing to successful ICT integration:

- A school principal who promotes and encourages change
- Belonging to a supportive professional community within the school
- Contact with professionals outside of the school environment
- Time allocation for personal and group development

Ranaana Secondary School

The last school which responded to the questionnaire is the Ranaana Secondary School, which does not consider itself particularly successful in ICT implementation so far, but wishes to share its experience as a means of assisting in the joint venture of improving the learning environment. This school is striving to integrate ICT as a means of encouraging students to become independent learner-researchers skilled in using the learning material wisely. It is considered here that no specific national strategies have helped in ICT integration, mainly because the Ministry encourages self-initiative in high schools. Although teacher training has been a long and ongoing process, the school did receive a few ICT teacher training courses aimed at two major goals.

1. Basic computer skills for teachers - Office and Internet.
2. The integration of ICT in the teaching/learning process, only for the more computer-oriented teachers.

The school curriculum dictates to a large extent curriculum content, and is directed towards succeeding the matriculation exam.

In all, the school is equipped with 65 Pentium computers (19 of which are connected to Internet), printers and scanners. The most frequently used applications include Excel, PowerPoint, PhotoShop, Internet and chat. At present just 15 out of 150 teachers (in particular, science teachers) use ICT in their teaching, but those that do consider that ICT enables them to spend more time with students having difficulties in learning. ICT technology enables students to practice in whichever subject area they choose, at their own level of knowledge. Collaborative learning increases in lessons combining computers.

A large amount of course material has been developed by teachers which integrates the use of ICT and is available to pupils on-line, either in the classroom or from home. This allows pupils to study independently, from home and at their own pace.

So far, only technology based training has been provided at the school, after school hours.

Pedagogical dimensions have not yet been covered in these courses. The ICT competent teachers are for the most part highly motivated, auto-didactic teachers who understand the benefit of using computers in education. They feel that unless ICT implementation is firmly steered by a strategic plan adopted at the Ministry level, few teachers are really motivated to integrate ICT in their classes, and those that do receive little support to progress in their endeavor.

Discussion and Recommendations

During the course of this survey, schools presented a number of criteria that they consider have determined their own successful ICT implementation. These can basically be combined into three categories which together define the ability of the school to integrate ICT into teaching practice:

- **school climate** (particularly evident in the experience of the Ranaana Secondary School in Israel), and considering such aspects as a shared vision for ICT implementation, commitment to the school-level strategy, information sharing within the school, work teams for specific tasks…
- **ICT management**: budget, modalities of the ICT implementation plan, technical support and teacher training, ICT maintenance strategies…
- **ICT knowledge**: purchase and upgrading of equipment, software and peripherals, pedagogical integration, modification of curriculum content, development of adapted assessment methods…

These three categories correspond to the constructs of a model used to analyse the innovative capacity of schools in a private study[18] carried out in Israel (see figure 1).

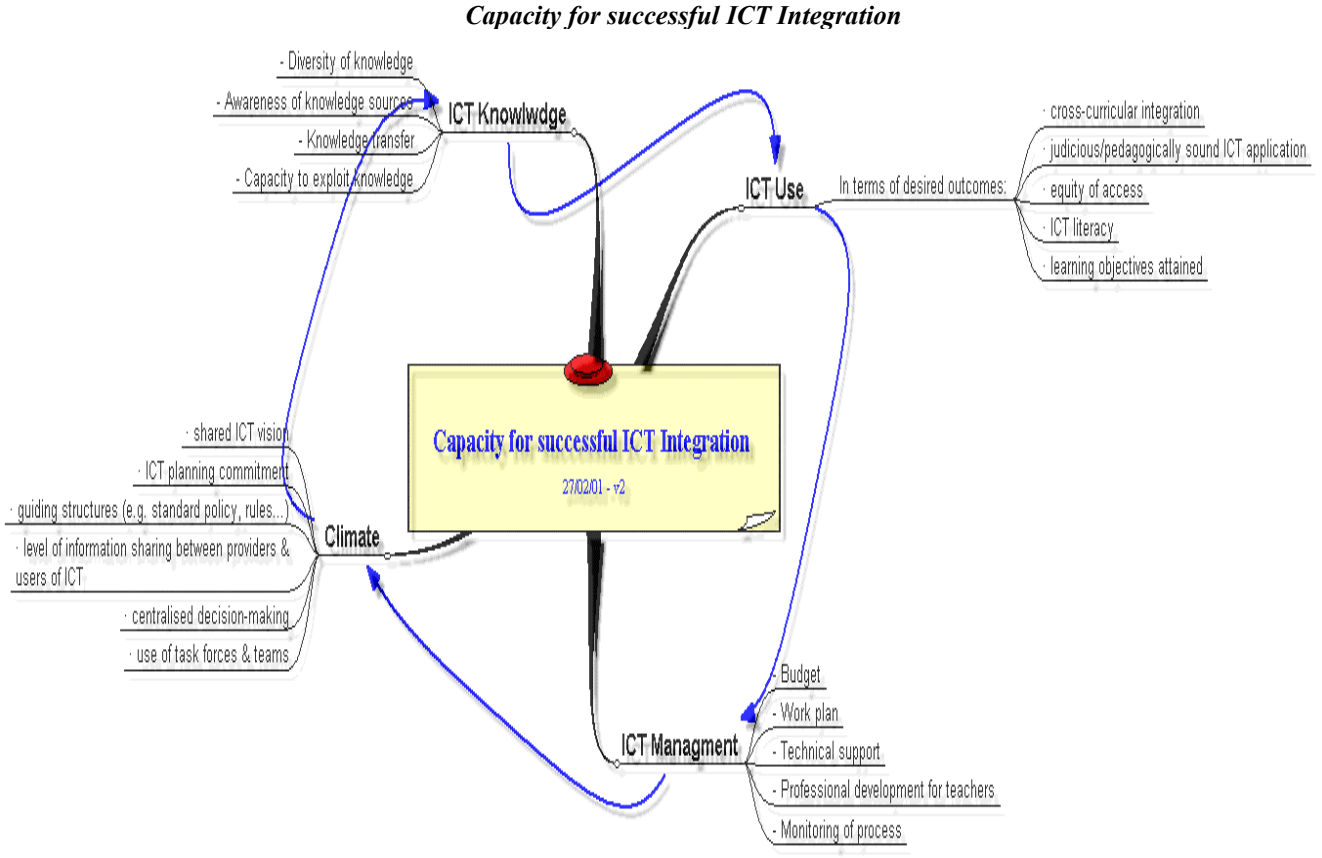

Figure 1: Model for ICT Integration in Schools[17]

This model was originally developed for determining the ICT integration capacity of private companies, but it could be very useful for analysing successful ICT implementation in schools. An in-depth case study on a broader number of schools would enable it to be further refined and completed for subsequent use as a tool that would provide schools with a guide and a check list to devise their own school-level implementation strategies.

A major concern that has become evident in the course of this study is the insufficient attention that is being given to two key research issues in ICT implementation: assessment methods in the classroom

and long-term assessment of outcomes of ICT-integrated learning. Before focusing on even more comprehensive ICT integration, it appears judicious to analyse the positive and negative effects ICT-based learning may be having on future citizens in order to ensure positive outcomes before it is too late. A further area of concern underlined by national authorities is the need to develop teacher trainers with a double expertise in pedagogy and ICT. Certain schools are overcoming an insufficient ICT-integrated pedagogy knowledge base by hiring ICT coordinator/directors, to work in collaboration with pedagogical adviser/directors appointed from subject area specialists within the school. This is possible for independent schools able to invest the required resources, however, it is not the case for most schools, which are forced to rely on more directive national initiatives.

Through the constant dialogue carried out with national and local authorities, teacher trainers, researchers and head teachers, a comprehensive network of implementation "experts" has been developed. Most of these express a profound interest in conducting an ongoing "poli"logue, in the form of an electronic forum or other, as a means of sharing ideas, enriching their own implementation strategies and learning from the successes and failures of others. Ongoing collaboration and "peer learning" in this domain could provide an important opportunity in tackling the challenge of the changes underway in education.

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http://www.fcar.qc.ca/ FCAR allocation strategies & university research projects

http://www.meq.gouv.qc.ca/drd/tic/pim.html#net ICT teaching/learning environment research

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http://vitrine.ntic.org/vitrine/veille/Textes/BIBecole2000.html
[5] This programme is presented at http://www.fcar.qc.ca
[6] Projects will be presented at http://www.fcar.qc.ca
[7] This programme is currently being reorganised and is presented at http://www.meq.gouv.qc.ca/drd/tic/pim.html#inno
[8] For presentation of the programme see http://www.meq.gouv.qc.ca/drd/tic/pim.html#net
[9] For presentation of the 41 educational content creation projects see http://www.meq.gouv.qc.ca/drd/tic/edition_proj.html
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