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Educational Opportunities on Canada's Information Highway: The Use and Deployment of Communications and Information Technologies in Education

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PREFACE

This paper provides an overview of how Communications and Information Technology (C&IT) and the Information Highway can be effectively used to educate Canadians. We realize that education is a complex issue, and that the delivery mechanism should be tailored to the particular needs and the delivery situation.

The methodology used consisted of consultations with key people involved in education and C&IT, as well as an extensive review of reports specifically on education and training, and of other publications and information sources on technology and the new economy.

The authors, while not educators, have a broad background in both economics and technology. This provides them with a very good understanding of technology-based applications, and the socio-economic aspects related to the Information Highway.

The paper proposes steps and fundamental elements for implementing technology-based solutions that meet the challenges of educating Canadians. Students educated with the help of technology-based tools should be better able to take advantage of the opportunities offered by the new information-based economy.

Finally, the authors wish to thank everyone consulted, as well as those who provided information used to prepare the report. Also, a special thanks to those colleagues who reviewed and commented on the numerous draft versions of the report.

EXECUTIVE SUMMARY

Education is an area on the verge of a major transformation. Numerous pressures have caused such a change. Changes to the Canadian economy, government cuts, demands from parents and critics are all factors influencing education reform. Surveys indicate that Canadians expect the Information Highway to provide a solution.

Education is also very visible, representing one of the largest expenditures in the Canadian economy ($55 billion), and Canadians appear to be dissatisfied with the results. It is important to note that the dissatisfaction observed appears to be at least partially related to studies that have widely disputed results in the educational community. The object of this report is not to analyse or criticize the results of these studies, but to use them as background information. This can help the reader understand the issues at stake, and provides an estimate of their potential economic impact. The most serious problems identified are:

- The illiteracy and numeracy problems estimated at costing the economy $4 billion a year;
- The significant drop-out rate — The Conference Board of Canada estimated that Canada could save $26 billion if the drop-out rate was reduced from the 1989 level of 34%, to 10% by the year 2000;
- Our students' poor results in international tests indicate that they are not keeping pace with students from other countries.

There are over six million elementary, secondary, college and university students in Canada studying in over 16 500 institutions staffed by almost 370 000 educators. Enrolment has been going up steadily since the mid-1980s. The schooling requirement for jobs is also increasing. By the year 2000, two thirds of jobs will need post-secondary education. Most importantly, the skill set is changing and we now require the skills learned or developed through the use of C&IT.

To understand how the Information Highway can be successfully used, we also need to understand the current situation of C&IT in schools, and examine the ways in which it is now being used. We cannot "throw" technology (the Information Highway) at the problem and expect to get instantaneous results.

Questions one must ask are: Is there anything in schools to connect to the Information Highway? How much will it cost? Who will pay? Will it be used? Is there content to access? What do we expect to accomplish? Will it replace busing, books, teachers, etc.? Answers are not easy. This paper attempts to identify the issues to be debated and perhaps provide some of the answers. These issues include the following:

- An insufficient amount of equipment found in schools today is capable of connecting to the Information Highway.

- Computers in schools are generally old and lack the sophistication needed to take advantage of the Information Highway.

- Computer penetration level is low in schools, with an average of one computer per 15 to 20 students.

- Technological deployment is often done through pilot projects.

- Generally, there is a low level of computer literacy among educators.

- Some educators lack an appreciation for C&IT, and generally are unaware of the potential capabilities of C&IT in the classroom.

- Successful deployment of C&IT is most often centred on highly motivated principals and teachers. Principals and teachers are the main catalysts of successful C&IT deployment.

- Technology in the classroom does not automatically guarantee better results for students.

- Technology in the classroom generally goes through three stages before achieving maturity: teaching about computers; computer-based learning/training; and using computers as a tool in the classroom.

- The use of C&IT for the Francophone community will be more difficult, as French-language software and information on the network is scarce.

A number of successful implementations of C&IT in Canada can be cited, but overall they represent only a small fraction of the potential for improvement through the use of technology. People must also realize that there is more to C&IT in education than tele-education and courseware. While these technologies are very visible, many of the most successful implementations use neither. We have determined that successful deployment of C&IT is closely linked to the following fundamental elements:

- Schools should become resource centres for continuing education. This would provide well-equipped centres for training, and would ensure that technological resources are used more effectively.

- Educators should work closely with industry, research centres and universities to ensure that the programs they develop are practical, useful and relevant to students' future requirements.

- Education should rely on a set of technical standards for hardware and software that permit the use of appropriate platforms for the task at hand.

- Technology deployment should be ongoing.

- Educators should seek the help of corporations and the community to deploy technology.

- Efforts should be made to ensure that rural and remote areas of the country are served adequately and at reasonable cost by communication networks.

The cost of improving C&IT in schools to take advantage of the Information Highway is very high, and would require a major shift in spending and curriculum delivery. We estimate that it would cost approximately $5 billion a year to deploy and maintain a high level of technology in schools. To make the deployment successful, a major training effort of educators would be necessary. To train the over 300 000 educators in primary and secondary schools for two weeks on C&IT would represent a 12 000 person-year effort. Teachers would also require ongoing training to stay current.

Results achieved through the successful deployment and use of C&IT can be dramatic. A number of examples where C&IT has had a major impact are noted in this report. For example, researchers observed that social interaction and co-operation in problem-solving are enhanced,

that students are focussed on the task at hand, and that "average" students can excel. Successful deployment can also reduce the cost of education and time to learn while improving retention rates.

We believe that nine steps can be taken immediately to address the situation and prepare education for the arrival of the Information Highway. Without this, the expectations of Canadians vis-à-vis Information Highway services will not be met.

1. The provincial and federal ministers responsible for education and the Information Highway should collaboratively undertake the development of a strategy to deploy technology in education.

2. Seed funding should be provided to form an association of organizations interested in technology in education, which will maintain a national resource centre on the subject. The centre would make available documents from all the Ministries of Education and other sources related to technology in education. The association could organize local and national conferences and provide training for educators.

3. A network of research centres in the field of technology-based learning from across Canada should be formed. These centres should disseminate the results of their activities, and thereby increase their profile. Funding could be provided to support research in the use of technology, to determine the impact of new technologies on learning, to determine the best practices and to facilitate the deployment of those most promising. The alliance would work closely with the faculties of education to transfer the knowledge of its members to new teachers being trained and to the professors teaching them.

4. Following the example of many provinces, the federal government should provide public education and learning institutions with access to the government inter-city services at periods of low usage. More than one million hours on the digital network could be made available for teaching, at minimal cost to the federal government. This would give institutions the opportunity to radiate their expertise across the country. This would be of particular benefit to continuing education programs.

5. Funds should be provided to conduct several (10 to 20) case studies on the cost and benefits of supporting technology-assisted education compared to the traditional system. The case studies, based on a common methodology, would be representative of different needs from across the country.

6. Seed funding should be provided for small initiatives for educators to stimulate the use of technology in the classroom using a model similar to that of the Education Technology Centre of British Columbia through its Technology Development Project Grants (TDPs).

7. Statistics Canada should gather and disseminate comprehensive statistics related to technology in education. Such statistics are currently unavailable, either nationally or on a regular basis.

8. The development of French content on the network, and of software to take full advantage of the opportunities offered by technology-assisted learning, should be supported. The current lack of French resources on the network makes the use of networks to access information in French schools very ineffective. Funding for Aboriginal languages content should also be considered.

9. Help should be provided in the formation of co-operatives to purchase C&IT equipment, services and software, to benefit from volume pricing and to reduce redundancy.

The use of C&IT in education appears to be very effective when it is well implemented, but the implementation and ongoing costs can be high. Over the past decade, many experiments have been carried out and best practices have emerged. If the lessons learned from these projects were used in the widespread implementation of technology in schools, the results could be dramatic. The large sums of money invested could be offset by making Canadians better prepared to find employment. The use of C&IT provides a more enjoyable learning environment that could help reduce the drop-out rate, and increase retention rates and overall academic achievement.

Drop-out, illiteracy and numeracy problems cost several billion dollars each year to the Canadian economy in lost productivity, lost earnings, and unrealized tax revenues, as well as in additional expenditures to address related social problems. If technology in schools could address only part of these problems, the investment would be quickly and easily repaid.

I. INTRODUCTION AND METHODOLOGY

Education has been touted as one of the most promising areas in the development and deployment of the Information Highway. This comes at a time when education reform, cost containment of public expenditures and international competitiveness are also at the forefront of the political agenda.

Recently, the Canadian Advanced Technology Association (CATA) released the results of a survey of its members concerning the Information Highway.[1] The survey reported that 90% of the respondents considered that remote learning and distance education held the greatest economic potential for suppliers of the highway, surpassing video on demand. A survey of the Canadian general public, by Andersen Consulting and Gallup, also indicated that educational services on the Information Highway represented the highest level of interest among Canadians surveyed, with 58.7% of respondents indicating an interest.[2]

"Educational services on the Information Highway represent the highest level of interest among Canadians."

In 1990, the federal and state administrations in the United States set six major goals for education. Goals have also been set by other private and public organizations with a stake in improving results in education. All these goals are very ambitious, and will probably require significant use of technology. Although we are not aware of specific national goals in Canada, provincial ministries of education have taken steps to reform the school system to reduce costs and to improve performance.

The purpose of this paper is to stimulate discussion on the use of the Information Highway in education. It provides a general background on the educational system; relevant statistics for situational analysis; an overview of the use of information technology in education and Communications and Information Technology (C&IT) initiatives in Canadian schools; the potential uses for C&IT in education and learning; and a brief description of activities in the United States. It also identifies issues concerning the introduction of C&IT in schools and preliminary cost estimates.

"Studies have also shown that computer-based instruction is cost-effective, enabling more learning in less time."

The paper is the result of consultations with over 100 people across Canada and the U.S. representing ministries of education, school boards, school officials, institutions of higher education, other agencies actively promoting the use of technology in education, C&IT hardware and software manufacturers and service providers. The research also involved a comprehensive review of documents on education, learning and C&IT.

New education applications could help make learning more stimulating for all of Canada's youth. Computers in the classroom and access to electronic information databases could make Canadian schools more exciting places to be. C&IT in schools can be used to provide a more challenging and stimulating environment. Such an environment could encourage more Canadians to stay in school to pursue higher levels of academic achievement. Studies have also shown that computer-based instruction is cost-effective, enabling more learning in less time.

If the introduction of C&IT in schools can even partially address the serious drop-out, illiteracy and numeracy problems, which cost the Canadian economy billions of dollars each year, the investment required may be repaid in a short period of time.

NOTES TO SECTION I

[1] CATA, KPMG, *Racing Towards Millennium - Survey Results*, (Toronto: RTM Conference 1994).

[2] Andersen Consulting, *The Information Highway Gallup Canada 1994 Survey - What Canadians think about the Information Highway*, (Canada: Andersen Consulting, Canada, 1994).

II. A STATISTICAL OVERVIEW OF EDUCATION IN CANADA

Canada's educational system is undergoing a critical public review to ensure that it is providing our youth and workers with the skills they need to adapt and compete in an information-based economy. The future needs of Canadians for knowledge and skills, and the ability of the system to satisfy those needs, have become a matter of national concern and a major public policy issue.

This section provides an overview of some facts and issues surrounding the Canadian educational system. General information on enrolment, number of teachers and number of schools is included to illustrate the size of the system. An examination of the costs of education is included, along with a review of some of the key issues facing the educational system, such as strains on education budgets; rising drop-out rates; literacy and numeracy problems; and questions surrounding the quality of education. These issues have been studied extensively and have been identified as serious concerns that require resolution. It is important to note that the findings of some of the reports used have been widely disputed in the educational community. The object of this report is not to analyse or criticize the results of the studies, but to use them as background information. This can help the reader understand the issues at stake, and provides an estimate of their potential economic impact. The aim of this paper is not to critique the educational system, but rather to examine these issues in the context of exploring how C&IT can be a tool to help resolve them.

FEDERAL-PROVINCIAL JURISDICTION

The responsibility for the delivery of education in Canada rests with the provincial and territorial governments. Each province and territory has developed its own system of education, and the structure can vary from jurisdiction to jurisdiction. Financial responsibility is usually shared between the provincial and local governments.

The role of the federal government is to address the educational needs of those who are outside provincial jurisdiction: Native people, armed forces personnel and their families, and inmates of federal prisons.

The federal government is also responsible for the Official Languages Education Program, and the Canada Student Loans Program. Provincial and federal governments share the fiscal responsibility for trade and vocational training and retraining.

SOME FACTS ON EDUCATION

1993-94 (estimates)

Education Level	No. of Institutions	Enrolment (Full-time)	No. of Teachers (full-time)*
Elementary/ Secondary	16 231	5 360 900	300 797
University	69	585 200	37 880
College	203	365 065	27 690
TOTAL	16 503	6 311 165	366 367

Table 1

Source: Statistics Canada, "Advanced statistics of education, 1993-94", Catalogue 81–220, September 1993.

**Also includes some non-teaching academic staff (principals, department heads, subject supervisors, senior administrators).*

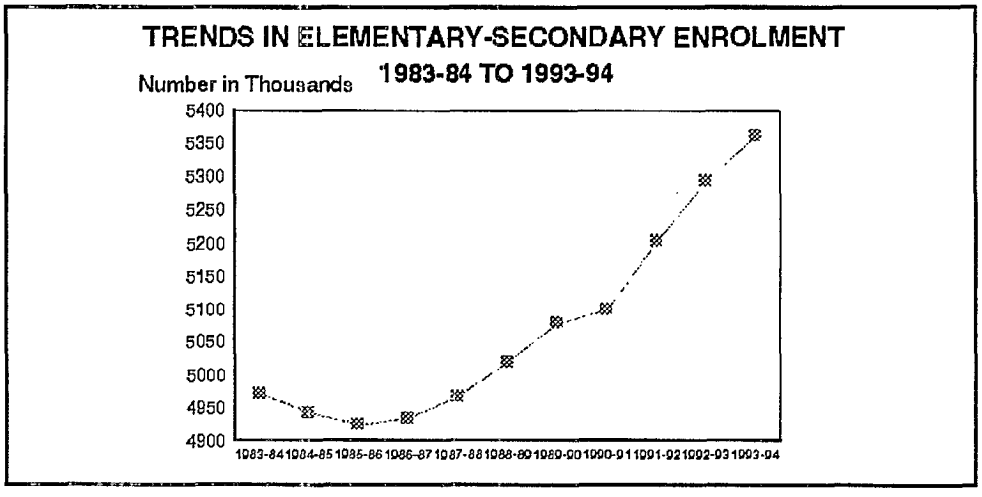

Figure 1

Source: Statistics Canada, Catalogue 81-220 and "A Statistical Portrait of Elementary and Secondary Education in Canada."

THE COST OF EDUCATION

Spending on education has risen steadily over the past decade, growing from $22.2 billion in 1980-81 to an estimated $55.5 billion in 1993-94. For 1993-94, this spending, averaged over the working population, was $4 275 for every employed person.

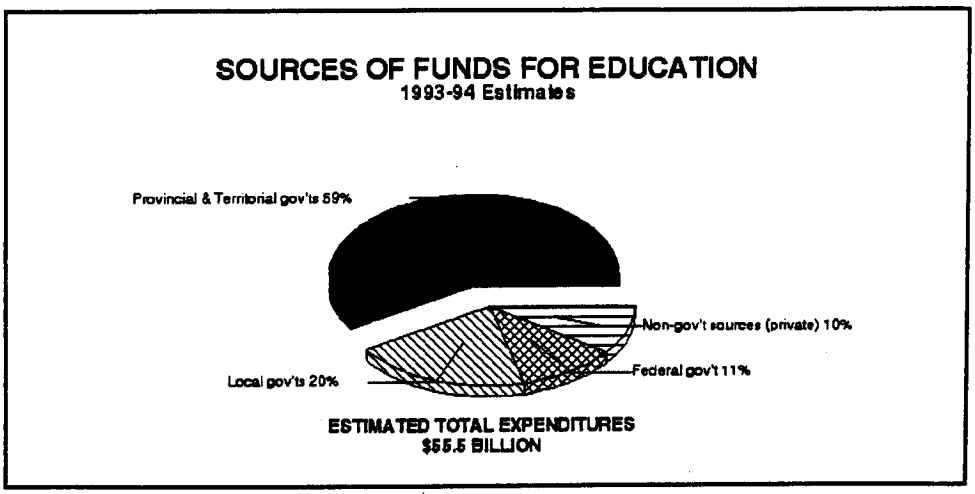

Figure 2
Source: Statistics Canada, "Advanced Statistics of Education," Catalogue 81-220, September 1993.

Governments finance more than 90% of total education spending in Canada. Education accounts for the third-largest outlay of public funds, following health and social welfare.

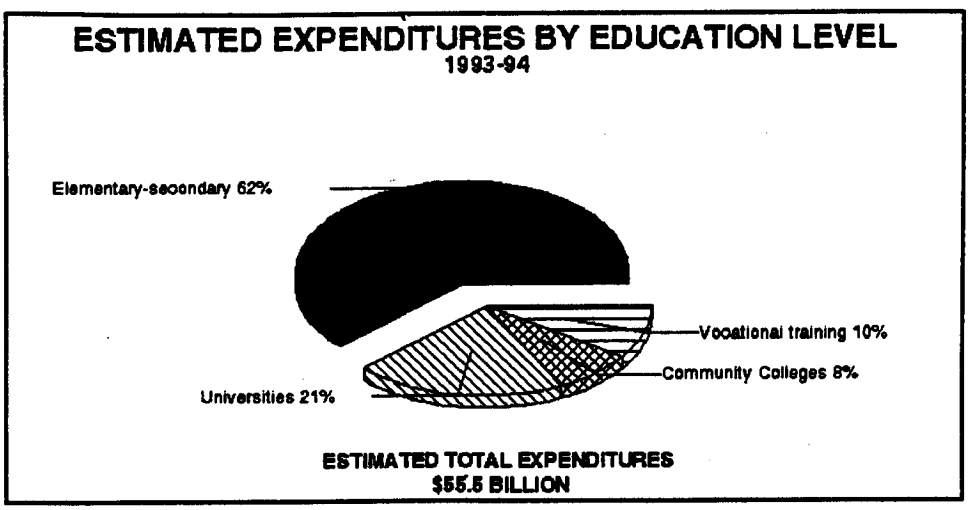

Figure 3
Source: Statistics Canada, "Advanced Statistics of Education," Catalogue 81-220, September 1993.

The majority (62%) of the spending is at the elementary and secondary level.

In 1989, public school boards across Canada spent $24.4 billion. The majority of this spending was for teachers' salaries. School boards receive the bulk of their revenues from provincial and territorial governments.

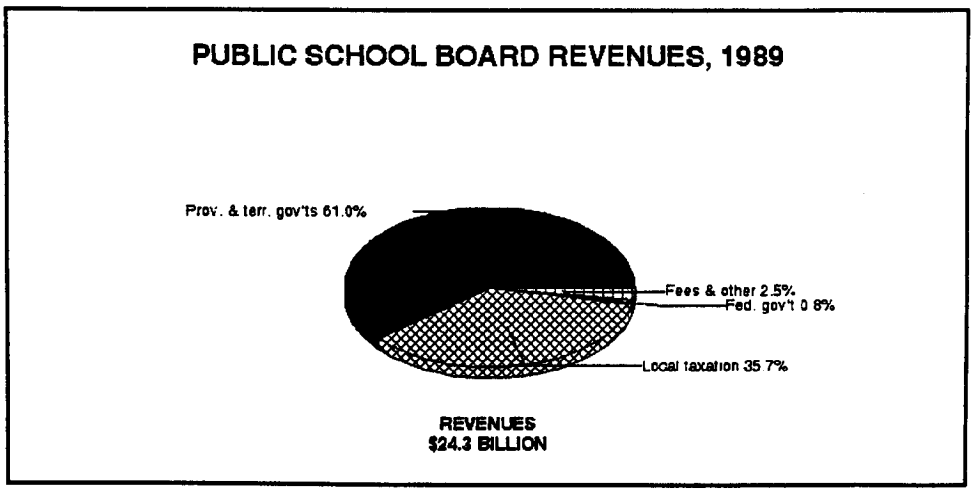

Figure 4
Source: Statistics Canada, "Financial Statistics of Education 1989-90," Catalogue 81–208, November 1993.

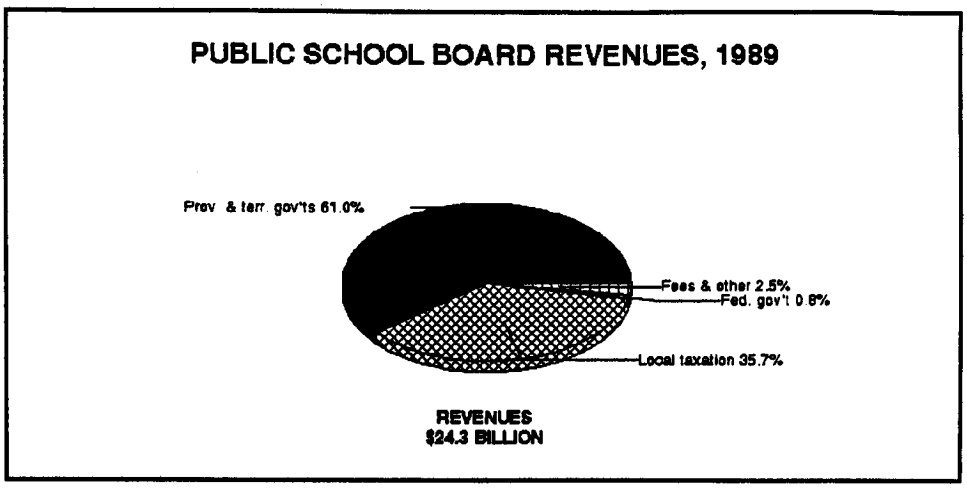

Figure 5
Source: Statistics Canada, "Financial Statistics of Education 1989-90," Catalogue 81–208, November 1993.

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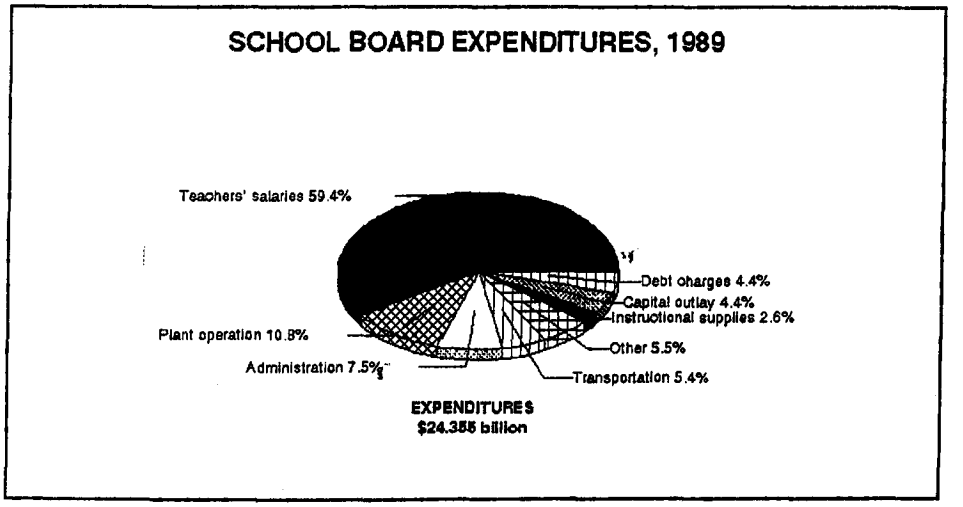

Expenditures on C&IT are not reported separately in the breakdown of school board expenditures. As these figures could be counted in numerous categories (instructional supplies, capital outlay, etc.), it is therefore difficult to estimate how much school boards are spending on C&IT.

The average local school board expenditure per elementary and secondary student in Canada was $6 134 in 1990. School board expenditures per student range from $4 454 in P.E.I. to $6 705 in Ontario.

SCHOOL BOARD EXPENDITURES PER STUDENT, BY PROVINCE, 1990

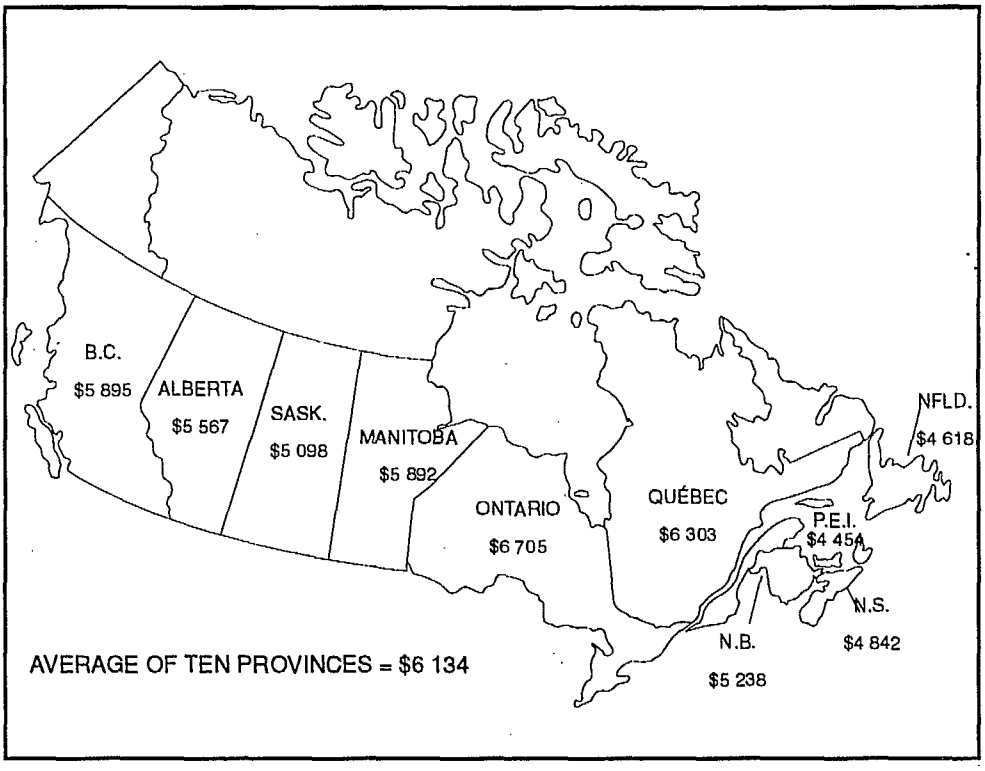

Figure 6
Source: Statistics Canada. Financial Statistics of Education 1989-90 — Catalogue 81–208, November 1993.

THE DROPPING OUT DILEMMA

Approximately one third of youths leave school before obtaining a secondary-school graduation diploma. In 1991, Statistics Canada surveyed 9 460 youths from 18 to 20 years of age.[1] The survey examined the environmental, social, personal and economic factors that may have contributed to youths leaving school prior to completion. The survey found that nearly one in four 20-year-olds had left school at some point in the past. Based on this same sample group, unemployment rates were twice as high for the drop-outs. And nearly half of those who had quit school regretted the decision.

Of all the jobs created between 1990 and the year 2000, it is projected that 64.5% will require a minimum of 12 years' education and training. It is therefore even more important that we encourage our students to stay in school, to prepare them for the job markets of the future.

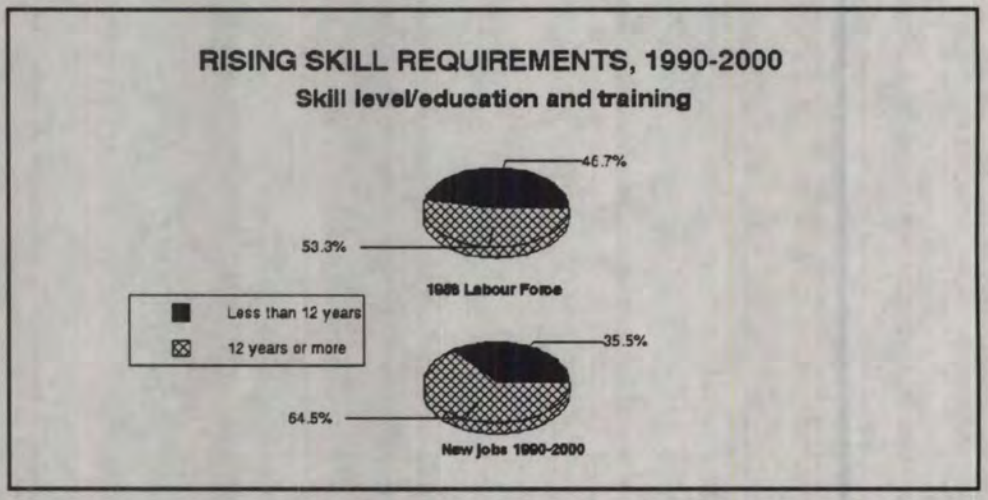

Figure 7
Source: Employment & Immigration, 1991, cited in a Conference Board of Canada report, "Dropping Out: The Cost to Canada," by Brenda Lafleur, March 1992.

Not only does dropping out cause problems for the individual, there are also large economic costs to society as a whole. A 1992 Conference Board of Canada study, Dropping Out: The Cost to Canada" [2] stated that Canadian society will lose more than $4 billion over the working lifetimes of the nearly 137 000 youths who dropped out instead of graduating in 1989. The economic cost of $4 billion consists of lost earnings and unrealized tax revenues, as well as the additional expenditures society has

to make to address related social problems. This study concluded that Canada could save $26 billion if the dropout rate were reduced from the 1989 rate of 34% to 10% by the year 2000.

Any initiative or tool that encourages students to complete their secondary-school education can have a positive impact on the future economic well-being of both the individual student and Canadian society.

These tools must help address the issues that cause students to leave school in first place.

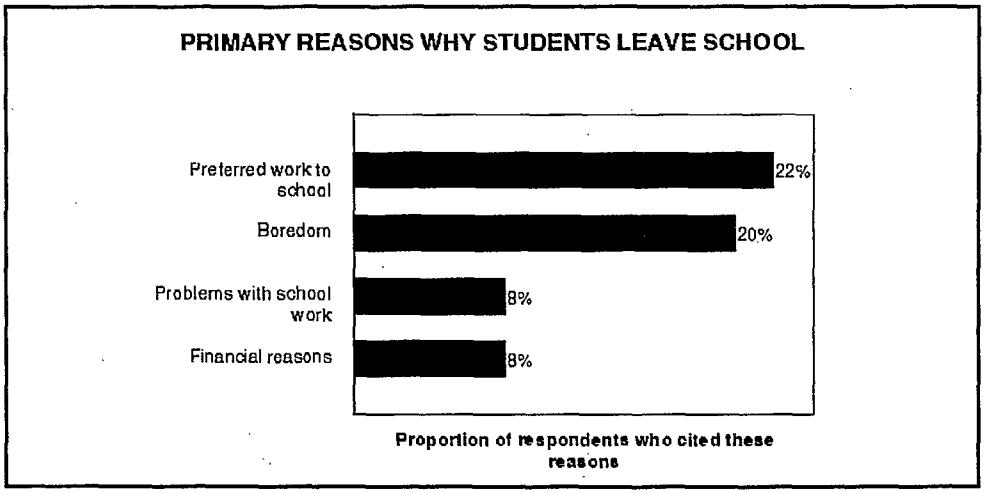

Figure 8
Source: Statistics Canada, "School Leavers Survey," 1991.

FUNCTIONAL LITERACY/NUMERACY

The level of reading and writing skills required for most occupations and tasks in Canada has been increasing over the past 50 years, and is likely to continue to do so. For example, during World War II, a Grade 4 level of education was required for entrance in the military, while today a high-school diploma or its equivalent is required. It has also been found that 90% of jobs require two to three hours of reading on a daily basis, and that about 70% of that is at a Grade 9-12 level of difficulty.[3] One can presume that numeracy requirements are similar. As the educational requirements of the work force are rising, there will be more and more Canadians without the necessary literacy and numeracy skills required to function in our increasingly complex economy. In 1991, Statistics Canada looked at the literacy skills and numeracy skills of Canadians aged 16-69.[4]

In the area of reading skills, the majority (62%) of Canadian adults (16-69) have adequate reading skills to deal with most everyday reading requirements. However, 22% of the adult population can only use reading material that is simple and clearly laid out and that deals with tasks that are not too complicated, and 16% had reading skills that are too limited to deal with everyday reading demands.

In the area of numeracy skills, once again, the majority (62%) of Canada's adult population have numeracy skills sufficient to handle everyday numerical tasks. However, 24% do not possess the necessary skills to meet most everyday requirements, and another 14% have very limited skills.

As expected, literacy and numeracy skills have a strong and positive relationship with level of schooling. Literacy and numeracy problems are most heavily concentrated among the adult population whose education is limited to elementary or no schooling whatsoever. Although

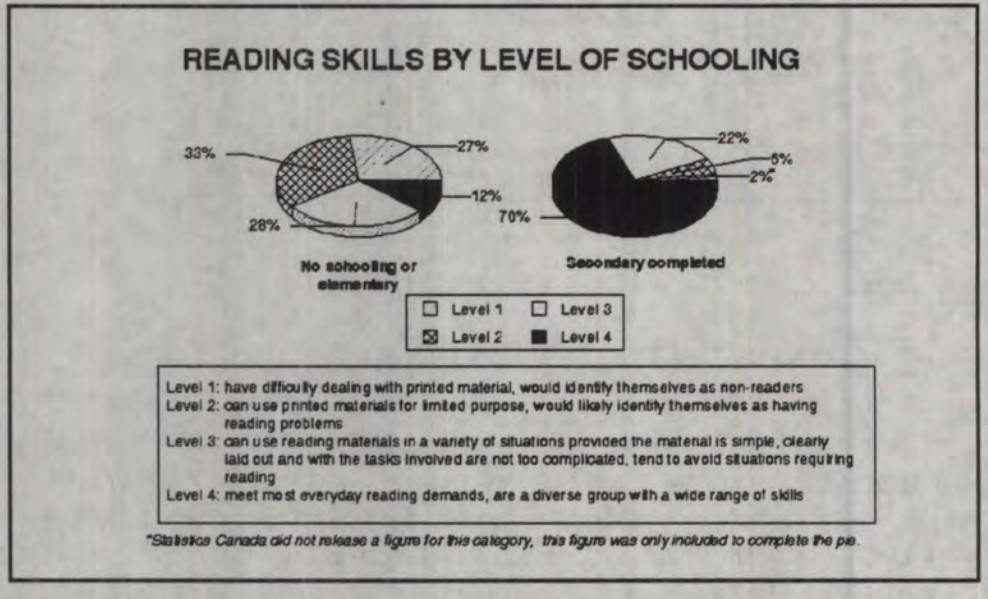

Figure 9
Source: Statistics Canada, Catalogue 89–525, "Adult Literacy in Canada", 1991.

the majority of those who have completed high school are functionally literate, there are still approximately 30% of high-school graduates without the necessary skills to meet everyday reading demands.

Similar results are observed for numeracy. About one in three adults whose highest level of education is high-school completion does not have the numeracy skills necessary to perform most everyday numeracy tasks.

There is also a strong relationship between age and reading skills. Older Canadians (55-69) are much more likely to have reading problems. However, it is alarming to see that 28% of those aged 16-24 had skills below the everyday reading level. According to the Economic Council, if this trend of youth illiteracy continues, "we will add to the labour force over the next 10 years at least another **million** young people who will have less than full functional literacy and/or numeracy."[5]

Many economic costs are associated with illiteracy, including costs to the individual (below average income levels, above average unemployment and reduced labour mobility), costs to business (productivity losses, errors in input and processes, reduced product quality, and problems of job reassignment), and costs to society (foregone output due to lower productivity in the work force, higher prices as a result of increased production costs, higher levels of income transfers, and higher costs for training programs).[6] Although no studies have been found that estimate the economic cost to society of these potential one million young people with inadequate literacy and/or numeracy skills, one can assume the figure would be significant. However, a study done in 1988 by the Canadian Business Task Force on Literacy[7] estimated that the annual cost to Canadian businesses from lost productivity due to illiteracy was $4 billion. This figure may not be statistically accurate, but it provides an order-of-magnitude estimate of the impact that illiteracy in the workplace has on employers.[8]

INTERNATIONAL COMPARISONS OF ACADEMIC ACHIEVEMENT

One way of assessing Canada's educational system is to compare our students with other students from around the world. It should be noted that it is difficult to make fair international comparisons, since educational systems vary from country to country.

Many reports and test results are available that compare Canadian students' academic results with their international counterparts. The Economic Council studied these results and in its report, "Education & Training in Canada" concluded that the "fragmentary evidence provided suggests the following:

- Canadian mathematics and science education is relatively strong at the age level of 9 or 10.

- By the age of 13 or 14, the performance of Canadian students, generally, sinks below the mean for industrialized countries.

- Canadian performance is relatively weak by the end of high school, even after adjustment for years of schooling and retention rates."[9]

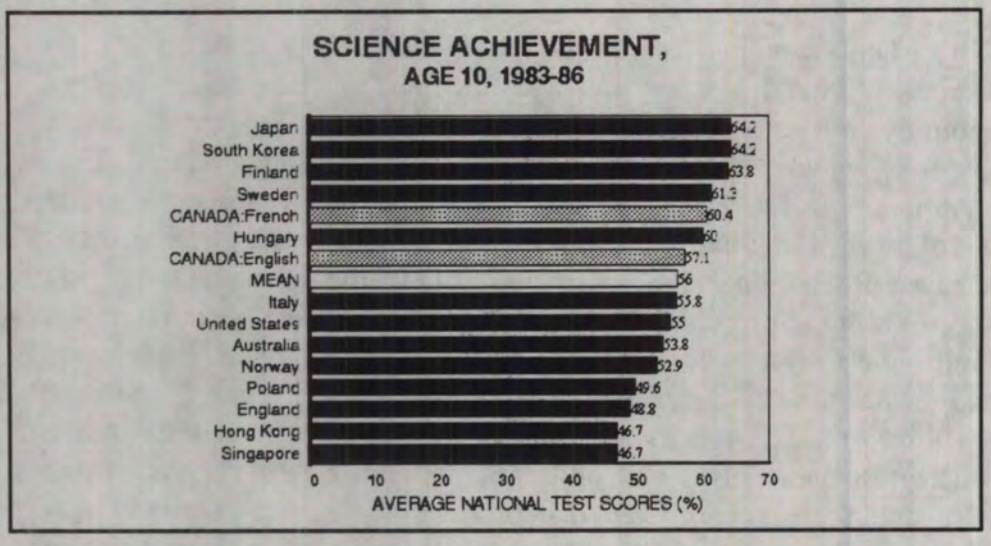

Figure 10
Source: Estimates by the Economic Council, based on the findings of the Second International Science Study.

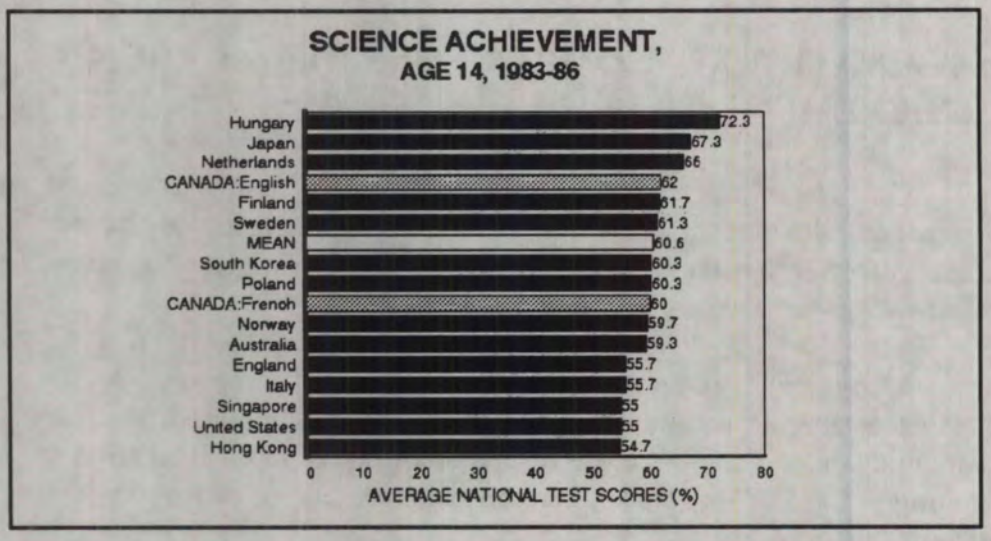

Figure 11
Source: Estimates by the Economic Council, based on the findings of the Second International Science Study.

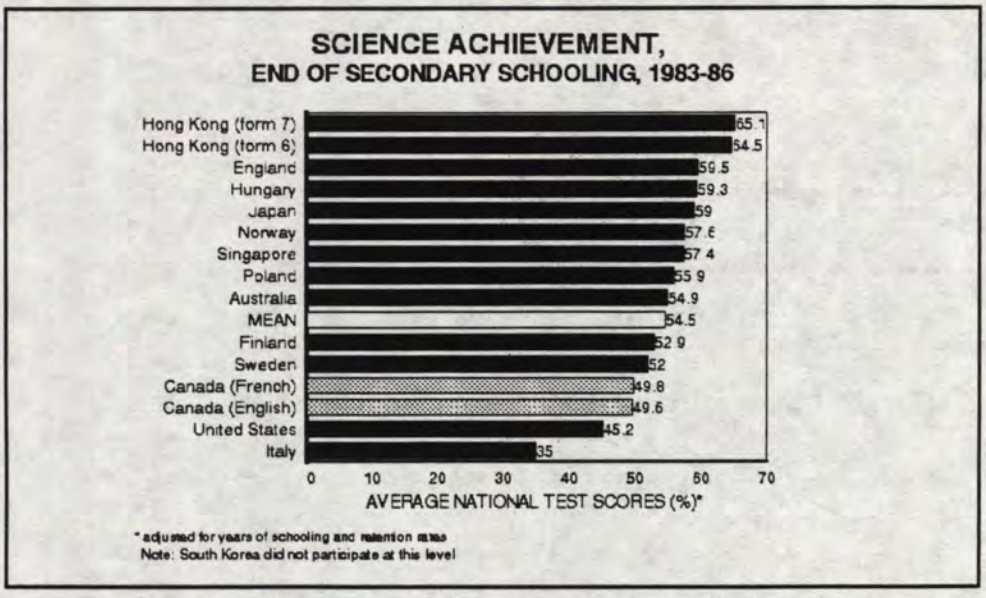

Figure 12
Source: Estimates by the Economic Council, based on the findings of the Second International Science Study.

Strength in science and math will be very important for the labour market of the future. The emerging labour force must have the necessary skills if Canada is to maintain a competitive position in the global economy. If these test results are any indication, Canada will not have the highly skilled work force it requires. Measures must be taken to ensure the science and math skills of our students are on par with our competitors. If we do not take action now, our domestic companies will lose their competitive position and we will have problems attracting investment into our country.

The reason for our poor performance is unclear. It could be attributed to a lack of interest in math and sciences; science and math courses that do not motivate or excite; or a lack of positive role models, or mentors, in these fields. Whatever the reason, steps must be taken to get our youth interested and involved in math and sciences.

It is not that teens do not appreciate the importance of science and math to their future success. According to the Industry, Science and Technology Canada (ISTC) survey, Pepsi Street Beat IV (1993),[10] the vast majority of teens believe science and math will be important to their future success, and very few believe that they will be able to get by without math and science. The 85% of teens who are taking science or math courses were asked what changes could be made to make these courses more enjoyable. They listed four activities as being most likely to increase enjoyment: doing more experiments; doing more hands-on work;

developing a mentor program; and making the course more applicable to daily life.

CHANGING SKILL SET

SCANS: Workplace Know-How[11]

COMPETENCIES - effective workers can productively use:

- Resources - allocating time, money, materials, space and staff;
- Interpersonal Skills - working on teams, teaching others, serving customers, leading, negotiating, and working well with people from culturally diverse backgrounds;
- Information - acquiring and evaluating data, organizing and maintaining files, interpreting and communicating, and using computers to process information;
- Systems - understanding social, organizational, and technological systems, monitoring and correcting performance, and designing or improving systems;
- Technology - selecting equipment and tools, applying technology to specific tasks, and maintaining and troubleshooting technologies.

THE FOUNDATION - competence requires:

- Basic Skills - reading, writing, arithmetic and mathematics, speaking and listening;
- Thinking Skills - thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning;
- Personal Qualities - individual responsibility, self esteem, sociability, self-management, and integrity.

The Canadian Economy has been undergoing a major transformation over the past few years. This trend will continue for some time. Our industrial and resource-based sectors are now taking a back seat to the information-based sectors. The by-product of this trend is the shift from a manufacturing to a service-based economy. Gathering, processing and analysing information are the tasks that will bring wealth to Canada. These are the skills required for the new economy.

Workers' tools have changed: we moved from paper to computers; from lathes to computer-assisted manufacturing; from local libraries to international information databases; from the filing cabinet to document imaging systems; and from the address book to the personal digital assistant (PDA). Most of this transformation has occurred since the early 1980s, when microprocessors became more commonplace. The little greeting card that plays "Happy Birthday" when you open it has more processing power than existed in the entire world before 1950. PDAs have more processing power and memory than the original IBM 360 mainframe computer.

As the facts and figures indicate, the educational sector is facing a significant challenge. Decision makers in the educational sector are looking for more cost-effective methods that will permit them to continue offering the quality education Canadians have been accustomed to. They are also searching for new tools that will help develop the skills our youth will require for the job markets of the future. C&IT education applications may provide the answers.

NOTES TO SECTION II

[1] Statistics Canada, Education, Culture & Tourism Division, *School Leavers Survey (one-time only survey).* (Ottawa: Statistics Canada, 1991).

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[6] T. O'Neill & A. Sharpe, "Functional Illiteracy: Economic Costs and Labour Market Implications," in *Adult Literacy in Canada*, Statistics Canada, Catalogue 89-525, 1991.

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[8] ibid.

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[10] Pepsi Street Beat is a national survey aimed exclusively at Canadians aged 12 to 19. Co-sponsored by Pepsi-Cola Canada, YTV Canada, Inc., and the federal government departments of Health and Welfare, and Industry, Science and Technology, Pepsi Street Beat takes a comprehensive look at the lifestyles, attitudes, values and dreams of Canadian teenagers.

[11] Lewis J. Perelman, *School's Out — Hyperlearning, the New Technology, and the End of Education,* (New York: William Morrow and Company, Inc., 1992).

III. ROLE OF COMMUNICATIONS AND INFORMATION TECHNOLOGY (C&IT) IN EDUCATION

OVERVIEW

It is important to understand that the use of the Information Highway in education, as in other fields, is dependent on our ability to connect terminals to it. In particular, telephones, computers, televisions, video cameras, video-conferencing equipment and local networks are the primary terminals for this purpose. In our research, we found that only a few schools in Canada are well equipped to connect to the proposed network and take advantage of the opportunities provided by the Information Highway.

"All computers in schools, including the vintage machines from the early 1980s, provide an estimated penetration ratio of computer-to-student equivalent to one computer for 15 to 20 students."

Television sets have been available in most schools since the 1970s. They were followed by the VCR, which slowly displaced the 16mm projectors used by teachers to illustrate and enhance their lessons. In the early 1980s, personal computers were introduced in the classrooms and in the mid-1980s, provincial governments made formal plans for computerizing schools. Provincial governments, particularly in Ontario and Quebec, used their large purchasing power to try launching a microcomputer industry in their respective provinces. According to our research, all computers in schools, including the vintage machines from the early 1980s, provide an estimated penetration ratio of computer to student equivalent to one computer for every 15 to 20 students.

A study of the U.S. Department of Defense concluded that the new computer-based tools could reduce the time to learn by 30%.[1] (Findings are based on defence training, but they may provide an indication of the potential benefits for general education.) It is important to note that computers do not necessarily replace teachers, but can contribute to their effectiveness. Dr. Tony Bates, of the Open Learning Agency in B.C., questioned, "...do we want children to learn social skills primarily through machines, or through direct interaction with other children? Do we want to develop machines to a level of sophistication that allow teachers to be

replaced?"[2] A blend of traditional and self-paced teaching activities will probably provide the balance. C&IT can provide opportunities for students having different learning styles not usually favoured by traditional instruction.[3] Multimedia can be used to help in the learning process. Studies indicate that people retain only 20% of what they see and 30% of what they hear, but 50% of what they see and hear and as much as 80% of what they see, hear and do simultaneously.[4] Following observations at River Oaks Public School in Oakville, Ontario, a primary school that has been successful in introducing C&IT directly into the curriculum, researchers reported that students working on interactive media tasks were highly focussed (84% work on task) whether the teacher was present or not.

"[The NII] estimated that only 18% of computers used in schools today are not technically obsolete."

A recently released report of the U.S. National Information Infrastructure (NII) entitled "A Transformation of Learning: Use of the NII for Education and Lifelong Learning" estimates that only 18% of computers used in U.S. schools today are not technically obsolete.[5] The number of computers in the U.S. school system is estimated at 2.5 million, or approximately one per classroom, and only 38% of teachers surveyed had access to a modem. Therefore, if the NII were available today, only 18% of classrooms in America could take full advantage of the system. As reported in the previous section, the ratio of computer to student in Canada is poor, and very few of these machines, in our estimate, would meet the requirements set by the NII for a multimedia terminal.

In most schools, audiovisual and C&IT tend to be concentrated in labs or technology rooms, and students have access either individually or through their classes. Because students are given access on a scheduled basis, e.g. on Tuesdays between 9:30 and 10:30 a.m., technology is not being used spontaneously.

"In most schools, audiovisual and C&IT tend to be concentrated in labs or technology rooms."

In many cases, there was a distinct trend in the use of computers in schools based on the maturity of their introduction. This may be linked to the penetration of computers and the comfort level of teachers with the technology. Three levels of computer use were identified:

1) teaching about computers;
2) computer-based learning/training; and
3) using computers as a tool in the classroom.

When first introduced, schools tend to use computers as a subject to be taught, usually in a lab setting. Next, computers are used with educational software and as a reward for other classroom activities completed. The last level appears to be the use of computers in the

classrooms as a tool to access information, prepare school work and communicate with others through electronic mail. At this level, the student-to-computer ratio is more favourable, and students hand in diskettes or e-mail their assignments. With the introduction of technology, the teacher is no more the "sage on the stage" but is now the "guide on the side," leaving the student the opportunity to explore. This last group, in our opinion, is the only one prepared to take full advantage of the Information Highway. Only a few schools in Canada fall into that category.

"The successes that a school achieves in the existing bureaucratic system are the direct result of acts of creative insubordination by principals."

Principals and teachers have often been at the centre of successful deployment of technology. An article in the New York Times reported: "... the successes that a school achieves in the existing bureaucratic system are the direct result of acts of *creative insubordination* by principals."[6] The success of the River Oaks Public School can be attributed to the leadership of its principal and the support of the teachers. A similar case is the superintendent of the South Bay Union Schools in California, who was able to invest over $3 million from school budgets into computers, network and software.[7] Currently, schools find that the introduction of technology is too expensive for the tight budgets available today. If schools want to take full advantage of the Information Highway, there must be someone to take charge who has the clout to influence a change in budget priorities. Unfortunately, however, there are few incentives for principals and teachers to be "pioneers."

"[The new Windows operating system] will need a bare minimum of 8MB of RAM, 50MB of free disk space to install, and it is recommended that users get a hard disk with a capacity of over 200MB."

Efforts to introduce technology must be sustained to keep up with technological advancements. We estimated that computers could not be more than two technology generations behind in order to use the latest software and connect to networks. Each generation now lasts approximately 18 months. Some computers still in use today in our schools date from the early 1980s and are not able to process more than eight bits of information at a time. In contrast, the technology available today for the desktop can process 64 bits of information. Memory (RAM) and hard disk capacity are also concerns as new operating system, application and network software require larger amounts of memory. For example, some new application software such as that based on Kaleida's Script X, a new multimedia application development environment, require 12MB of RAM to operate, a capacity well above 95% of systems available in schools. The new Windows operating system (Chicago) has similar requirements. It will need a bare minimum of 8MB of RAM, 50MB of free disk space to install, and it is recommended that users get a hard disk with a capacity of over 200MB.[8] Also, schools must equip themselves with CD-ROM readers to take advantage of the wealth of educational products and information sources now available in CD format.

Schools have networks and computers of many different architectures, which creates a problem of compatibility and restricts the availability of software. New platform-independent application development software such as Script X should be widely available soon. This will not address all compatibility issues or requirements, but could reduce development cost and increase market size for software producers, while providing users with a choice of hardware architecture. Operating systems capable of controlling hardware of different architectures, such as Windows NT or Unix, may also be a key to addressing this issue. However, these two architectures were not designed for the K-12 education market, as they are too complex, but there are plans for other alternatives that would address these issues.

INFORMATION SOURCES

A number of information sources are available on-line in Canada and around the world, most of which can be accessed free via the Internet. CD-ROMs are also used in many institutions as an excellent source of information. However, there are some issues surrounding on-line information that must be addressed.

One such issue is the concern over students having access to *all* information available. As information is freely accessible, students can potentially access inappropriate or offensive information. To deal with this, filters need to be put in place to make such content difficult to access from student accounts.

"French represents less than 10% of Internet sources."

Another issue is the lack of French content available on-line. Since the predominant language for on-line information is English, the Francophone community will have access to only a small portion of the information available. The number cannot be estimated readily, but French represents less than 10% of Internet sources. French universities in Canada and those in countries of "la Francophonie" should be made more sensitive of this issue, and should be encouraged to make available additional on-line material and sources. Teachers in Quebec are also concerned that there are no "good" encyclopedias available on CD-ROM.[9]

Both the Canadian Cable TV Association (CCTA) and Stentor, under the Beacon initiative, have announced plans to provide some services to schools. While reaching schools is important, reaching students in the classroom is even more desirable. CCTA members are forming a new, not-for-profit organization called "Canadian Cable in the Classroom" (CCC), which will provide free connection to cable TV service through

local cable companies. They will distribute educational programming to French and English schools, royalty free. Educators will be able to record the programs and present them in their classrooms at a later time. However, the low penetration of TVs and VCRs in schools may make it difficult for schools to take full advantage of the service. So far, the details of Stentor's plans have not been made public.

USE OF C&IT IN EDUCATION

Communications and Information Technology can be used in a variety of ways within the school system. C&IT is often viewed as synonymous with tele-education, while others see it as an information-gathering tool. For some, C&IT in education is seen more as a tool for administrating the school than as a tool for students. We have identified numerous ways in which C&IT can be used for education.

Tele-education

Tele-education refers to the use of telecommunications to extend education services to areas that do not have access to a classroom-based teacher, and is, in effect, an extension of correspondence schooling. Numerous technologies have been used to do this. The application, budget and the sophistication of the users usually determine the choice of technology. According to experts interviewed, it appears that the younger the students, the better the quality must be, in order to retain their attention. Higher quality translates into a higher cost for the institution.

Types of tele-education systems available include:

Audio-teleconference;
Audio-teleconference with electronic chalkboard, tele-writer, fax;
Audio-teleconference with computer conferencing;
Computer-based conferencing and e-mail (alone or in support of audio and video options);
Individual e-mail boxes for students and teachers;
Virtual classrooms using virtual reality, MUD and MOO technology.

(MUDs and MOOs were created to play sophisticated computer games, but the technology has been touted as a way of providing a virtual school or campus. Students can interact with teachers and peers over the network without physically meeting.)

Two-way video-conference using low bandwidth (56 - 384kbps);
Two-way video-conference using medium bandwidth (384kbps - 1.5Mbps);
Two-way video-conference using high bandwidth (1.5 - 45Mbps) or full broadcast analogue equivalent;
One-way video-conference with audio feedback from remote sites (see video options above);
One-way video using broadcasting system.

Help to communicate with the home

Technology can also be used to communicate with parents at home. Some schools have introduced voice mail systems to keep parents informed of school activities and homework, and to provide advice on certain subjects. Parents and students can also leave messages for teachers. The technology allows students and staff to quickly produce school voice "newspapers." Hot-lines have been set up to provide students with help with homework assignments and advice with other problems. Some schools are also using electronic bulletin boards to provide similar services and to make documents available such as minutes and agendas for PTA meetings. For example, Vanderbilt University in the Nashville, Tennessee, created an electronic messaging system called Classnotes for parents and teachers to access homework assignments and leave messages for teachers. The system has produced a 15% improvement in student performance, including higher grades and a greater rate of homework completion. In addition, parent-school contact increased by 33%.

Types of systems used to help to communicate with the home include:

Answering machine or audio announcement accessible through the phone;
Voice mail;
Computer bulletin boards and e-mail to teachers and students.

Computer-based education

Education provided automatically by computers connected to networks, capable of adjusting to the requirements of every student, is a technical possibility, but reality is much different. A number of schools are using the technology to a certain extent. Computer-based education includes software modules providing self-paced courses capable of giving student feedback and evaluation. An example is the Thomas Haney

Secondary School in Maple Ridge, B.C., where the students learn at their own pace by completing instruction modules on computers.

Computer-based education also includes other uses of computers in the classroom such as experimental simulation. An example is the simulation of physical phenomena using computers. This helps the student to understand such phenomena by providing them with the opportunity to control and change variables. Dr. Pierre Nonnon of the Education Faculty, Université de Montréal has experimented with a concept called "Lunette cognitive," [10] which provides students with an environment to carry out computer-controlled physics experiments. Some schools in the U.S. have been provided with access to external computing resources. Students can experiment with software models for fluid dynamics or weather forecasting residing on supercomputers such as the NASA HPCC program.

Types of systems used in computer-based education include:

Eduware (software used as replacement for teachers, personalized education software supporting self-paced learning):

Text only;
Text and graphics;
Multimedia;

Self-contained multimedia systems (e.g. CD-I technology developed by Phillips Electronics);

Access remote computers for processing information (e.g. Telnet, SLIP, PPP).

Computing as a tool

As schools have better access to computer resources, students start using the technology to produce reports and homework. They use computers with "regular" programs (i.e. word processing, spreadsheets, databases, Hypercard) to process information.

Students can also learn to control simple machines with computers. Many students in elementary schools use Lego robotic kits to animate machines they have created with software they also designed on classroom computers.

C&IT used to search information locally or remotely

Numerous sources of information are available on-line locally or around the world. Students can access them by connecting through a local Internet access point. Information in the form of text, software, images and video can be searched and retrieved. One example of this is SchoolNet.

Types of C&IT systems used to search information locally or remotely include:

Access to Gopher, Archie, Veronica, WAIS, Mosaic, etc.;
Access to remote databases FTP, etc.;
Access to CD-ROMs.

C&IT used to communicate with students, teachers and outside resources

At times, students need to communicate with others to discuss projects and get additional information from teachers, mentors or experts in specific fields. The Canadian SchoolNet project provides discussion groups and e-mail capabilities for students and teachers connected to the Internet. For example, students at River Oaks Public School have used desktop video-conferencing to connect to a school in Japan to collaborate in a joint study of environmental issues in the two countries.

Types of C&IT used to communicate with students, teachers and outside resources include:

Newsgroups;
Bulletin boards (BBS);
Electronic mail (e-mail);
Telephone;
Desktop video.

Schools radiating to the outside world

A number of schools in North America have set up servers to provide information about their school to others. The Lincoln Elementary School in Iowa and the Illinois Mathematics and Science Academy (IMSA) in Aurora, Illinois are some of the best examples of this use of networks. IMSA's system provides information on the school's extra-curricular activities, clubs and organizations, as well as the minutes and agendas of PTA meetings.

Types of systems used by schools to radiate to the outside world include:

Mosaic site;
Gopher site.

School administration

School administrations have made progress in using C&IT to perform centralized tasks. In Quebec, la Société de gestion du réseau informatique des commissions scolaires (GRICS) is responsible for the management of the computer network linking all school boards. The network is used mostly for administrative purposes, to access remote computing resources and to exchange information. To a lesser extent, the network is also used for pedagogical applications. A report of a survey conducted for the Ministère de l'Éducation du Québec, indicates that school administrators, teachers and staff use the current C&IT resources to carry out approximately 20 different tasks, from management of their personal agendas to management of students' academic and behaviourial records.[11] The report also identifies approximately 100 new administrative tasks they would like to see computerized and networked.

NOTES TO SECTION III

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[3] Austin Clarkson, J. Durlak and K. Pegley, *Creative Applications for Multi-Sensory Interactive Media Research Summary*, (Ontario: Halton Board of Education Technology Implementation Project, December 1992).

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[7] Lewis J. Perelman, *School's Out...*

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[10] Pierre Nonnon, *Laboratoire d'initiation aux sciences assisté par ordinateur - la lunette cognitive*, (Montréal : Université de Montréal, Faculté des sciences de l'éducation).

[11] Guidotti, *Rapport d'entrevues....*

IV. FINDINGS

The information in this section has been derived from interviews and documentation sent by various organizations from across the country. This is not an all-encompassing compendium of the activities in Canada. Our goal was to provide a good overview of examples of C&IT use across the country. For complete references of the documents used, see the bibliography.

DISTANCE EDUCATION

Distance education has been around for many years. Distance education and open learning in Canada have evolved from basic correspondence courses to technology-based activities. This section focusses on technology-based distance education activities — tele-education.

"Technology-based distance education can play a role in helping to alleviate the education gaps and disparities across the country."

Technology-based distance education can play a role in helping to alleviate the education gaps and disparities across the country. To date, it has not been cost-effective to offer a broad choice of course curriculums to small and remote communities. With an Information Highway in place, it will be easier to provide all Canadians with access to the same level of education in terms of choice and quality. For example, in today's situation, children in remote communities usually receive the most basic education (the three Rs). Students who are interested in pursuing advanced courses such as calculus or physics — prerequisites for some university programs — are often forced to either travel long distances or not take the course at all.

Most provinces provide some form of tele-education. The following is an overview of some distance-education initiatives being undertaken across Canada.

- In **Newfoundland, TETRA** - The Telemedicine & Educational Technology Resource Agency, a pioneer in the field of distance education, provides a distance-education production and delivery facility with a mandate to expand the use of distance-education techniques and technology by public- and private-sector users. TETRA owns a teleconference network throughout Newfoundland and Labrador, with a total of 207 sites in approximately 112 communities. The agency provides print, television and teleconferencing services.

"TETRA owns a teleconference network throughout Newfoundland and Labrador, with a total of 207 sites in approximately 112 communities."

The present teleconferencing system is enhanced by the use of telewriters. Telewriters enable the exchange of handwriting and computer graphics via personal computers and special modems that allow simultaneous transmission of voice and data on the same telephone line.

Twenty-five percent of their programming is in the area of education. Eight high-school courses are offered: three French, two Physics and three Mathematics courses. These courses are taught to 65 rural schools across Newfoundland and Labrador. In total, 750 students participate in these courses. Other educational offerings include: over 30 credit courses from Memorial University's (MUN) Division of Continuing Studies; MUN's first- year university program; various courses from the Marine Institute and Provincial Colleges; and several seminar-type training sessions for various organizations.

- **Nova Scotia** has a project called **High School Distance Education** that began February 1, 1994. There are six small schools (less than 125 students) involved, and there will soon be eight. It is an audiographics system that runs on Network Nova Scotia using Vis-à-vis technology. Four courses are currently being offered: Grade 12 Biology, Accounting, and Global Geography, and Grade 11 Entrepreneurship. At night and on weekends, communities take advantage of the network by using it to teach post-secondary courses offered by various colleges and universities in the province. In 1994–95, 16 high-school academic courses will be offered during school hours.

- **Network Nova Scotia (NNS)** is an expanding distance-education system in **Nova Scotia** that links public schools, community colleges and universities. All sites share a common network backbone and scheduling system, which permits any site on the network to originate or receive courses from any other point on the network. NNS is operated as a partnership between the Department of Education and Maritime Tel & Tel, and is based on a unique telecommunications tariff structure for education that is not geographically biased. NNS consists of 18 community-college sites (currently using audio only), CommNET, which links four community-education centres in Cape Breton, four post-secondary sites and the seven-site Collège de l'Acadie (a distributed French-language community college without walls). The entire network shares a common audio network, and 15 sites are equipped with audiographics.

Each Collège de l'Acadie site is also equipped with video-conferencing. Plans are currently being developed to add audiographics to each community college site and to establish mobile training centres that can be located within business and industry.

- **TeleEducation NB** is a distance-education initiative in **New Brunswick**. It has been set up as a five-year project under the Canada-New Brunswick Co-operation Agreement of Entrepreneurship and Human Resource Training. The project is seen as "a leading catalyst in the province's Information Highway initiative."[1] It is operated under the authority of the New Brunswick Department of Advanced Education and Labour.

"TeleEducation NB is seen as a leading catalyst in the province's Information Highway initiative."

  An audiographic teleconferencing system makes up the core network, supplemented by video-conferencing at certain sites. There are currently close to 50 sites established in college and university campuses, schools, hospitals, community centres, First Nation reserves, private companies and libraries in all regions of the province. TeleEducation NB supplies the computer teleconferencing equipment needed for course delivery, initial staff training and ongoing support. The communities and institutions delivering the courses on the network provide the site/facilities and the basic equipment required (486/33MHz IBM compatible machine, printer, fax machine, photocopier, TV, VCR and audiocassette players).

  The budget allocated for the five years is $10.5 million, two thirds from the federal government and one third from the province. The project has two components: TeleEducation NB network, which has $6.1 million to set up and maintain the technological and organizational infrastructure; and the Program Development Fund with $4.4 million to support the development and adaptation of courses for distance-education delivery.

  TeleEducation NB does not offer courses on its own behalf, but serves as a delivery vehicle for public and private educational and training activities. Universities, colleges, secondary schools and private companies all deliver courses on the network. Some examples of courses offered include: Mount Allison's unique multimedia computing distance-education course in first-year Physics and Astronomy; New Brunswick Community College (NBCC)-Miramichi's computer-based training package courses; NBCC-Moncton's teaching of AutoCAD through software sharing at multiple locations; and NBCC-Edmundston's delivery

of courses in the Hospitality program. All network services are bilingual.

"Télé-université is the only Francophone university in North America that specializes in distance education."

- In **Quebec, Télé-université** is part of the Université du Québec's network of campuses. Created in 1972, it is a single-mode open university, meaning all of its courses are offered at a distance. It has an enrolment of approximately 25 000. Télé-université provides thousands of adults with the opportunity to pursue university-level courses without leaving their homes. Most of the students are working adults studying part-time.

  Course content, exercises, exams, readings, etc. are all sent to the student via various media forms, such as phone, telematics, TV, video and audiocassettes, and printed material. There is also a tutor assigned to each student to provide telephone assistance throughout the course.

  Telematic applications are used in two ways: to provide interpersonal and inter-group communications and guidance through e-mail links, computer-based conferencing and telematic conversations; and to provide for the "teledistribution"/ transmission of interactive subject matter, such as databases, glossaries, directories of useful addresses, a document research program, automated exams and exercises. Students access these telematic applications via the Université du Québec network, Datapac, Edupac, etc. Although students may have access to a computer lab, most work from their own work stations.

  The courses offered are in the field of communications, informatics, humanities and social sciences, administration, education, and science and technology. These courses are all sanctioned by the Université du Québec. In addition to short programs or certificate programs, Télé-université also offers a bachelor's degree in communications, and a master's degree in distance education/teaching (aimed at training teachers to be distance educators). In addition, researchers at the Télé-université are examining different aspects of distance education, including public networks, intelligent networks, the use of new technologies in distance education (hypermedia, telematics, and expert systems), computer-assisted text analysis, navigational tools, and user interfaces. Télé-université is the only Francophone university in North America that specializes in distance education.

Other universities in Quebec are actively working on providing distance-education services to complement classroom-based offerings.

- **Contact North** was established in 1986-87 with the aim of improving Northern Ontario residents' accessibility to formal secondary and post-secondary education. It is an audiographic teleconferencing distance-education network that serves approximately 9 000 students in **Northern Ontario**. Over 110 communities are served, including many very remote communities that are not even accessible by road. There are access sites in all Northern Ontario secondary schools and post-secondary institutions.

  Each access point is equipped with a variety of educational technology devices, such as PC compatible and ICON computers, microphones and speakers for audio teleconferences, Telewriter II electronic blackboards, fax machines, and audio and videotape recorders. Students do a portion of the course work on their own using instructional packages (print material, audio and videotape), and they periodically participate in telephone conferences with students in other communities and with the teacher.

  Contact North does not offer courses on its own behalf, but serves as a delivery vehicle for many educational institutions. In the 1993-94 academic year, 8 953 students were registered in 587 credit courses at the secondary or post-secondary level.

  The network is funded by the Ontario Ministry of Education and Training. Contact North's annual operating budget for 1994-95 is almost $5 million. A portion of this money will also fund the testing of the technical and pedagogical applications of multi-point multimedia conferencing in Northern Ontario. To complement the efforts of Contact North, the Northern Distance Education Fund (NDEF) was created to encourage colleges and universities to develop self-study distance-education instructional materials. Since 1986, over $7.5 million has been allocated to the development of over 200 credit courses.

"Contact North was established in 1986-87 with the aim of improving Northern Ontario residents' accessibility to formal secondary and post-secondary education. It is an audio-conferencing/ audiographics distance-education network that serves approximately 9 000 students in Northern Ontario."

- **TVOntario** was created to provide all Ontarians with equal access to television-based learning opportunities. One way they do this is by broadcasting curriculum-based programming at the elementary and secondary levels on their English (TVO) and French (La Chaîne) networks.

At the post-secondary level, course materials are developed as a collaborative venture between TVO and the post-secondary institutions. The universities and colleges establish the curriculum and are responsible for student registration, tutoring, examination and assignment of credit. The TVO and La Chaîne networks produce and acquire tele-courses on behalf of the post-secondary institutions, and make television and other course components widely available through the institutions, their network broadcasts and tape-distribution services. Currently, TVO broadcast schedules and post-secondary course offerings are tightly co-ordinated at Lakehead University, Laurentian University, Mohawk College, University of Windsor, Queen's, Western and Wilfred Laurier. The French-language network, La Chaîne, is working closely with Glendon College, Laurentian University and the University of Ottawa, as well as with diverse Quebec colleges and universities through the CANAL network.

Once a student has registered for a course, the participating university or college sends the student the required learning materials along with instructions and information on broadcasts, possible teleconferences, meetings, workshops, assignments and exams. An instructor or tutor is assigned to each student to provide guidance and feedback on the student's progress.

For the 1993-94 academic year, approximately 15 first- or second-year credit telecourses in business, English, fine arts, French, geology, political science, psychology, religion, economics, statistics, chemistry and sociology were broadcast in English on TVO and nine courses in different areas were broadcast in French on la chaîne.

Besides broadcasting and distributing educational programming and support materials, TVOntario is also piloting TVO Online and ChaîNET, English and French on-line systems. These are currently networked to eight school boards across the province, serving 5 000 users. Teachers participate in on-line focus groups, exchanging viewpoints and ideas on issues in education and providing feedback to TVOntario on educational programs and services. Participating teachers provide network access to students who enter the dialogue in their own conferences, and submit documents for discussion by other students across the province.

Some other distance education initiatives in Ontario include:

Franco-Ontarian Distance-Education Network: A multimedia distance-education network using compressed video transmitted over digital telephone lines to deliver university courses in areas such as speech pathology and cardiology.

Guelph/Waterloo/McMaster Education Link: A long-distance interactive classroom using two-way audio, video and data links to deliver graduate level chemistry and physics courses. The program has recently expanded to reach McMaster University to include other program areas such as music.

Carleton University: Courses delivered using a dedicated cable television channel.

Open College - Ryerson: Diploma courses delivered using radio broadcast technology.

"In Ontario, at the university level, 5 000 to 6 000 full-time equivalent students or 30 000 enrolments are being served in over 800 distance-education courses."

It is worth noting that in Ontario, at the university level, 5 000 to 6 000 full-time equivalent students or 30 000 enrolments are being served in over 800 distance-education courses.

- **Manitoba Satellite Network (MSN)** provides a one-way video and two-way audio satellite television network linking sparsely populated sites throughout Manitoba. Approximately 800 high-school students, 400 first-year university students and 1 400 public- sector employees have participated directly in network activities.

- The **Evergreen and Lakeshore school divisions**, in the Interlake region of **Manitoba**, were looking for a way to continue delivering the quality education rural students need to compete in tomorrow's job market. Low enrolments were limiting the courses available to their students. They chose an interactive distance-education television solution.

  Their interactive television system is an analogue two-way audio and video network running on fibre optics between the four sites (the high schools in Arborg, Riverton, Gimli and Fisher Branch). Courses may be delivered from any site on the network. The instructor and students in each site can fully interact with each other. When the system was designed, an attempt was made to create an environment that closely duplicates a regular classroom setting (i.e. the teacher and all participants are visible at all times, microphones are voice-activated, etc.).

The system offers courses almost every period of the school day. The courses offered are Grade 11 French and Physics; and Grade 12 Math, Calculus, World Issues and Entrepreneurship. The maximum size of a class is 30 participants in total; the maximum per individual site is 12. Most classes have approximately seven students per site. The system has been found to work best for older, more motivated students who function well without a teacher present.

After school, the system is used for school-related meetings (teacher groups, committees, student council, etc.) and for adult continuing education courses offered three nights a week by Red River Community College in Winnipeg. The school divisions also rent the facilities to other groups for $35/hour.

- Other interactive television and video-conferencing systems in **Manitoba** include: the **Midland School Division**, which has been operating an interactive television system for the past four years using wireless technologies; and the **Swan River School Division,** which in 1994 piloted a video-conferencing studio based on ATM technology on fibre optic lines. This studio has been used for the delivery of university courses, electronic field trips, and for general community use.

- **Manitoba Education and Training** has released a request for information regarding available options for the development and delivery of a high-quality, multi-purpose, multi-user two-way video network for rural and northern Manitoba. The network would initially link up to 90 rural and northern communities with each other and with studios and classrooms in post-secondary institutions in Winnipeg, Brandon and Thompson.

- The **Eston-Elrose School Division** in **Saskatchewan** has been using video-conferencing since 1991 to allow teachers to conduct a single class for students in two separate communities.

- The **Saskatchewan Communications Network (SCN)** is an educational network consisting of:

    - The Training Network, which delivers live, interactive credit and professional-development programming.

    - The Cable Network, which distributes educational television programming via satellite from the University

of Saskatchewan, the University of Regina and the Saskatchewan Institute of Applied Science and Technology (SIAST). Thirty post-secondary courses were offered in the 1993-94 academic year. Students gather in a study centre at a designated time to view a televised presentation, participate in local and televised discussions and interact with the instructor. There are 58 study centre sites located across Saskatchewan. Professors for these courses are selected as "master teachers," noted for both scholarship and dynamic teaching style.

SCN is also available to other groups that wish to provide training and upgrading to a dispersed audience. For example: the Saskatchewan Alcohol and Drug Abuse Commission (SADAC) provides seminars for teachers, counsellors, social workers and health-care professionals.

SCN is also piloting a project to help efficiently distribute educational videotapes to all school sites by using VBI (Vertical Blanking Interval) broadcast. Instead of having video cassettes mailed to the school, VBI is used to control remote VCRs to record programs broadcast during off-peak hours.

- The **Yellowhead school district**, a rural school board near Jasper **Alberta**, stretches 225 kilometres along the Yellowhead Trans-Canada Highway 16. The school district has 5 300 students in 17 schools with school populations ranging from 25 to 800. The district has plans to install a 250-kilometre private fibre optics communication network for connecting the schools in the district.

  The network will provide a multiple channel, near-broadcast quality, two-way, interactive voice video network for distance education, employee professional development, training and upgrading, and administrative meetings. High-speed wide-area and local-area computer networks will distribute software, integrated learning system courseware, CD-ROM-based electronic resources, and will provide the medium for division-wide electronic mail. An integrated voice telephone system will complete the network to facilitate voice communications, voice mail, facsimile, and direct dial control connections.

The projected expenditures are as follows: $2.2 million for the fibre optic construction and materials; $2.4 million for the opto-electronics and network components; and $1.8 million for audio-visual, machine control and software, amounting to a projected total of $6.4 million. The district decided to build its own network, since the alternative was an estimated tariff of $6.7 million annually from AGT. To help offset some of the costs associated with owning the fibre, a condominium-type ownership arrangement is being discussed with a business partner.

Benefits to the school district include: a broader selection of junior and senior high-school courses available to their small community schools and the sharing of teacher expertise among all schools; providing alternative delivery structures allowing for more personalized instruction; the potential for post-secondary credit delivery to high-school students; and the potential for future linkage to other networks such as Alberta Educational Technology and Research Foundation (AETRF) and the Community Learning and Information Network (CLIN) in the U.S. The project will also provide many benefits to the community by giving non-profit community access during non-instructional time, particularly for continuing education, business training and job retraining.

- The **Alberta Education Technology and Research Foundation (AETRF)** is a co-operative partnership of business and educational agencies exploring the application of technology in the educational system. AETRF, a non-profit organization, has a board of directors that represents the key educational players in Alberta. The mandate of AETRF is to bring together businesspersons and educators to undertake educational research and development work. The Foundation's goal is to develop technology-based systems to improve the delivery and quality of education in Alberta. The specific objectives are:

    - to position Alberta on the leading edge of educational innovation and educational applications of technology;
    - to improve elementary and secondary education in Alberta to reach levels of student achievement and performance that rank with the world's best;
    - to plan and co-ordinate educational research and development activities that would make Alberta schools more efficient and effective; and

- to provide opportunities and assistance to Alberta businesses to develop, produce and market educational materials to Canadian and world markets.

Sixteen educational partners (school districts) and five business and technical partners (Ed Tel, AGT Limited, Northern Telecom, The Training Group and Syncrude Canada Ltd.) are involved in projects. There are over 25 schools, 77-plus teachers, 200 parents and over 400 students directly involved in a number of pilot projects. Pilot projects include:

- *Special Needs Pilot Project* - 14 schools and four other organizations are linked using Northern Telecom's VISIT personal video stations to provide on-site in-service sessions to teachers, electronic access to special education experts, electronic information access for teachers, and preliminary diagnostic and consultative services by specialists to students and teachers in rural schools.

- *Sharing Resources Pilot Project* - five high schools each have a fully equipped classroom linked by fibre to each other and to a site at the Alberta Teachers' Association building in Edmonton. The project will test the delivery of a variety of course modules among the schools, and will experiment with collaborative teaching and learning.

- *School to Home Pilot Project* - involves providing a class of students in four schools with laptop computers equipped with a modem. The students use the computers and the school BBS to do research and to complete assignments, which they electronically transmit to teachers. The parents use the computers to communicate electronically with the school.

- *TELS (Technology-Enhanced Learning System)* - a comprehensive, one-stop educational information management and delivery system being developed by AETRF. A working prototype is being tested in schools. Teams of teachers and students developed courseware for mathematics, science and social studies. The second phase of this pilot project involves developing the preliminary design specifications and standards for TELS.

The Foundation raised $500 000 from its educational and technical partners and received a $2-million grant from the Government of Alberta. As well, AGT Ltd. and Ed Tel have contributed several million dollars worth of network services to AETRF to be used with the participating schools.

- **Interactive Distance Learning** is an initiative headed by the University of Alberta and the University of Calgary, connecting eight sites (University of Alberta, University of Lethbridge, University of Calgary, Red Deer College, Athabasca University, Grand Prairie, Yellowknife and Whitehorse) with high-speed data communication. The purpose of the project is to find a better way to deliver curriculums at a distance. They have issued a Request for Proposal to AGT/Ed Tel/NWTel for a broadcast quality interactive video system. AGT has been very supportive, providing the universities with a trial tariff for the initiative. The trial is using Northern Telecom and PictureTel equipment.

"The distance-education courses at the University of Calgary have a very low drop-out rate (less than 5%)."

- **University of Calgary's Distance Education/Off Campus Credit Group** provides education services primarily to people off-campus in remote areas. Eighty centres across Alberta offer courses to remote classrooms using audio-conferencing with video enhancement. They are moving toward video-conferencing. Because instructors do not have a class in front of them when they teach, all students are in the same environment, i.e. no one has the advantage of being physically in the same room with the instructor. The university uses the Alberta provincial government lines after hours to reduce the cost of telecommunications. They are in the process of moving toward full-degree programs rather than just courses, mainly at the graduate level in the Faculty of Education. The distance-education courses have a very low drop-out rate (less than 5%).

- The **Open Learning Agency (OLA)** in **British Columbia** aims at providing high-quality learning opportunities appropriate to the needs of British Columbians. They fulfil this goal by creating more flexible ways of offering programs and services to learners, and by helping other institutions, organizations and employers to do the same. Through the OLA, learners are able to obtain courses from a wide range of sources, which they can study at home, in community learning centres, at work, or at education or training centres, depending on their preferences and needs. Credits, diplomas and degrees awarded by the OLA are fully transferable to other accredited educational institutions.

Approximately 30 000 individually enrolled, part-time, mature students are served each year. A further 30 000 per year are reached through the OLA's workplace training program. They also support 5 000 young people annually, who are in transition from school to work or to post-secondary education, and either need access to learning opportunities not available locally, or wish to complete high-school qualifications.

"Through OLA, learners are able to obtain courses from a wide range of sources, which they can study at home, in community learning centres, at work, or at education or training centres, depending on their preferences and needs."

Courses offered make use of multimedia and communications technology. Learners are linked electronically to instructors or tutors, as well as to computer databases. Courses are supplemented by face-to-face seminars, workshops or practical work. The OLA provides access to a wide range of specialized education and training channels (television, data and multimedia) in the home, the workplace, and educational institutions. These channels include: a publicly accessible television service; live television feeds from all over the world combined with on-line interaction with learners across the province; on-line access to "banks" of educational video and multimedia materials and remote computer databases; and on-line interactive services for education, such as computer networking and video-conferencing. Non-formal learning opportunities are primarily available through the OLA's general education TV channel. Seventy-five percent of the programming on this channel is Canadian. The audience for this service alone is one million per week.

The OLA has helped to establish a community campus network of local learning centres in 70 communities in B.C. Each learning centre is connected to the B.C. educational communications network.

The OLA plays a wide range of roles in the delivery of distance education in B.C. In some cases, it provides complete "turnkey" management of a program (design, development, delivery and accreditation), while also offering consultation services to individuals or institutions on how to design and deliver its courses. The Agency is the primary centre for the production and distribution of learning materials for other B.C. educational and training institutions. It also advises government, provincial educational institutions and private-sector organizations on standards, services and applications of communications technologies for education and training.

Funding for the OLA comes from a variety of sources, including: contracts with the Ministry of Education and the Ministry of

Advanced Education Training to provide a range of programs and services; contracts with other organizations to provide specific courses and services on a full cost-recovery basis; user fees; and funds from sponsors, corporate underwriting, donations from individuals, and investors.

- The **B.C. Ministry of Education** runs a project in conjunction with the OLA called **New Directions in Distance Learning (NDDL)**. The project is funded by the Ministry and the OLA looks after about two thirds of the operations. The program provides distance-education courses to 11 small secondary schools whose Grade 11-12 population is approximately 40 students. Next year, 16 schools will be involved. Five courses are currently being offered: Law, Biology, English, Data Processing and Accounting. Their target is eight courses in the future. NDDL also involves the development and delivery of a laddered career program for Grade 11 and 12 students in information technology/information management. A major component of the program will be the development of what is being referred to as a Career and Personal Planning Seminar, which will feature work experience for distance learners. NDDL is delivered through a combination of technologies, including computer conferencing, audiographics (Vis–à–Vis), audio teleconferencing and telelearning. The program also involves a mediated approach to distance learning and print support. One interesting note: one of the schools involved in this project had its first graduate, thanks to the combination of distance education and correspondence courses.

"One of the schools involved in the B.C. NDDL project had its first graduate, thanks to the combination of distance education and correspondence courses."

- In the **Northwest Territories**, the **Beaufort-Delta Divisional Board of Education** and the **Aurora Campus of Arctic College** (both centred in Inuvik) have had some success with an audiographic system for course delivery.

- The **Yellowknife Campus of Arctic College** recently taught a segment of its Adult Basic Educator training program using **Television Northern Canada** as a delivery vehicle (video out, audio back). They have also been experimenting with e-mail correspondence courses.

OTHER USES OF C&IT IN EDUCATION

As outlined in Section III, there are many uses of communication and information technology in schools that go beyond the traditional distance-education uses. The following section provides an overview of some Canadian schools that are doing innovative things with C&IT.

School-to-home communication

- **River Oaks Public School** in Oakville, Ontario is installing voice mail to provide information and feedback to parents on their child's progress. This may also include a message each day on activities of the day and assignments.

- The **Regina Catholic School Board** and **SaskTel** are testing voice messaging in two high schools using the telco's TalkMail service. Parents will be able to receive messages from the school and reply from their home phones.

Computer-based education

- **Thomas Haney Secondary School** in Maple Ridge, B.C. has moved away from teacher-directed instruction to self-paced, self-directed instruction. Their aim is to simulate an environment like the workplace, in which individuals are given assignments and must set the pace of their own work and establish realistic goals. They feel that the traditional educational system takes the spontaneity away from the student. The school, which has 700 students in Grade 8-12, is in its second year of operation. There are over 400 computers in the school (MACs and IBMs), and many courses are taught on computers using various courseware packages. The courses are divided into 20 units, and students are able to complete the required work as quickly or as slowly as they wish. For example, one Grade 8 student has already completed Grade 8, 9 and 10 math, while some students may require more time than a regular school year to complete all the units of work. When students have completed a unit of work, they go to see their marker, who determines whether they are ready to take the test for that unit. To move on to the next unit, students must attain a minimum of 70% on the test. If necessary, students may go back and redo the unit and retest. The students

"Thomas Haney Secondary School in Maple Ridge, B.C. has moved away from teacher-directed instruction to self-paced, self-directed instruction."

"Electronic busing delivery system uses a variety of technologies to enable the flow of ideas and information among learners and educators."

had excellent results on their government exams. The school has attracted students who require a more flexible school schedule, such as elite athletes who miss a lot of school because of competition and training, and students with health problems.

- The **Nechako School District** in **British Columbia** has developed an alternative means of using technology for educational opportunities — **electronic busing**. The delivery system uses a variety of technologies to enable the flow of ideas and information among learners and educators. Electronic busing provides a library of on-line and stand-alone learning resources. These resources are provided to each learner's home, and are available 24 hours a day, seven days a week. It is a home-learning environment providing quality educational programs in partnership with parents. A typical student on the electronic bus can expect the following services and equipment: 1-800 access for assistance and advice available 16 hours per day; an e-mail account; an Internet account; a preconfigured computer system (a leased 486 DX computer, a 14 400 bps fax/modem, and CD-ROM); an individually tailored software and curriculum bundle; in-house (on-site) technical support and service; a 24-hour on-line electronic teacher; a learning resources account for the acquisition of materials; evaluation, reporting and certification services; and access to standardized tests.

"La robotique pédagogique tries to reintroduce active learning methods by allowing students to acquire, through the planning, development and construction of a simple animated object, the functional scientific skills and concepts needed to create these robotic objects."

Computers used for experimental simulation and robotics

- Since the 1988-89 school year, **Ecole Hébert** in St. Laurent, a suburb of Montreal, has been using robotics to help teach the basic foundations of physics, chemistry, mathematics and algebra, and to provide an understanding of various technologies like mechanics, pneumatics, electricity, informatics and artificial intelligence. **"La robotique pédagogique"** is a project that tries to reintroduce active learning methods by allowing students to acquire, through the planning, development and construction of a simple animated object, the functional scientific skills and concepts needed to create these robotic objects. Students construct a mechanical object and use a computer with Logo programming to develop a graphic presentation of their project and to control the object. This innovative teaching method was conceived by professor Pierre Nonnon, director of the Laboratoire de robotique pédagogique at the Université de Montréal.

- **Burnaby South High School** in Burnaby B.C. has installed a video system, which includes 191 interactive TV monitors. Using a remote control or wireless keyboard, students can retrieve information from these monitors on laserdisc, CDI, still video, feeds from three satellite dishes, CD-ROMs, etc. Students and teachers can use the system for video-conferencing between classrooms and with other video-conferencing sites in B.C. such as hotels and universities. One use of Burnaby South's video system is to carry out scientific experiments. The teacher dissects one animal while her work is being projected on to a screen that every student can see clearly. As she works on the experiment, the camera can zoom in or show a variety of angles. The teacher can also choose to call up a laserdisc showing the same experiment. It should be noted that while such demonstrations are excellent tools for many learning situations, they do not replace hands-on learning experiences for students.

"First-grade students at River Oaks learn to do simple programming using Hypercard, which is used to "front end" many applications for the students."

C&IT as a tool

- **River Oaks Public School** has an above average number of C&IT tools available. The computer-to-student-ratio of one to three is much better than the national average. First-grade students at River Oaks learn to do simple programming using Hypercard, which is used to "front end" many applications for the students. One class is trying a Powerbook per student, taken home at night for homework. All students hand in diskettes containing homework and other assignments. The school is looking at making a file server accessible from home, which would provide students and parents with access to software and information.

"One use of Burnaby South's video system is to carry out scientific experiments."

- **Burnaby South High School** is another school with an above average computer-to-student ratio, at one computer for every five students. There are more than 400 IBM PS/2s located in the classrooms and computer labs. The computers are fully networked on IBM 16MB token-ring LANs that can carry up to 70 channels of video and audio in addition to computer data. The token-ring networks are connected to the school's fibre-optic backbone. The school also has a video system, as described earlier. The technology is used mainly as a tool to enhance traditional courses. For example, students are able to take advantage of the TV studio and the three editing suites to develop video reports, rather than traditional written reports.

- **William McDonald Junior High School** in **Yellowknife, N.W.T.** has 10 laptop 64K word processing machines available that students can sign out, either for long-term use or for short projects.

- **Bayside Middle School** in B.C. has internal e-mail, which students use for the submission of assignments. The e-mail tool, called Collaborative Learning Environment software (CLE), was developed based on the CMEC/DOC New Media Strategies in Education program. CLE has been specifically designed for younger children, and, given its client/server design, is capable of being run on low-end equipment.

- In **Quebec**, there is a pilot project to modernize e-mail in schools and to provide students with access to this tool. In 1993-94, 50 mail servers were installed as a pilot project providing services to over 50 school boards. It has been estimated that between 7 000 and 9 000 students used the system. In 1994-95, the project is expected to start its operational phase, with further deployment to other school boards.

- **Auburn Drive High School** in **Cole Harbour, Nova Scotia**, will open in September 1994 with over 300 computer systems serving 900 students. This fully networked school has video and multimedia production capability, with access from each classroom to a multimedia distribution system. This school has a unique partnership with MT&T, and houses the district-wide school library network.

C&IT used to search information locally or remotely

- The **Range Lake North School**, a K-8 school in **Yellowknife, N.W.T.**, has its library on-line as well as multiple CD-ROMs available to its students.

- The **River Oaks Public School** is doing collaborative work with a school in Japan using Vis-à-Vis technology.

- As part of its studies on South Africa and apartheid, a Grade 9 class at **William McDonald Junior High School** in **Yellowknife** has been communicating with people in South Africa over the Internet. Grade 9 students in the Challenge Program are exploring the Internet and Gopher, and are writing a scavenger hunt to be put onto their system for students to explore the network and Gopher services.

- The **North of 60 Bulletin Board** systems links all schools with telephones in the N.W.T. for electronic messaging and resource sharing.

- In **Trail B.C.**, the local FreeNet is being run out of the school district office. This gives the district's 3 500 elementary, middle and high-school students the ability to communicate electronically with libraries, databases and fellow students around the world.

- In **Nova Scotia**, 85 of the province's 492 schools have Internet accounts allowing them to communicate with the rest of the world. NSTN offered five accounts for each of the 22 school districts

- **Burnaby South Secondary School** has three satellite dishes for real-time TV broadcasts and video-conferencing from around the world. Examples of things they have done with this network include:

    - Video-conferencing by receiving a satellite video feed from an engineering association in London, for a lecture on physics concepts.
    - Multiple classrooms were involved in the Safari project, where students saw a live video and were able to converse with divers at a dive site. Since the school has a 650-seat theatre, students from other schools were able to come and participate in these live video feeds.

<u>Schools radiating to the outside world</u>

- **Burnaby South Secondary School** operates its own Gopher site. The school is also hoping to participate in a project to teach Earth Sciences over the Internet, using Mosaic, a World-Wide-Web (WWW)-based environment. The project also involves four U.S. schools and NASA.

<u>School Administration</u>

- **Beaver Valley Middle School** in **Fruitvale, B.C.** (part of the Trail school district) is using its computer network for school administration. School announcements that were once broadcast by loudspeaker are now distributed on classroom computer terminals. Teachers also use these same terminals to maintain

students' records, which are filed electronically with the school office. The electronic files are off limits to the students.

- The **Evergreen and Lakeshore school divisions,** in the **Interlake region of Manitoba** use their interactive TV distance-education network for holding school-related meetings (teacher groups, committees, student council, etc.)

- The **Baffin Divisional Board of Education** in the **N.W.T.** has set up a computerized accounting system to link its 20 schools.

C&IT SITUATION IN SCHOOLS ACROSS CANADA

"Most schools in Canada are not adequately equipped to take full advantage of the potential offered by the Information Highway."

Most schools in Canada are not adequately equipped to take full advantage of the potential offered by the Information Highway. No official figures are kept on computer penetration in Canadian schools. However, based on provincial figures available, we estimate that on average there is approximately one computer for every 15 to 20 students. It should be noted that this figure includes all computers. Commodore 64s and other vintage models from the 1980s are included in the total, and may give a false impression that adequate information technology resources are abundant.

This section provides an overview of the C&IT situation in some provinces. Unfortunately, information from all provinces is not available because in some cases this type of data is only gathered at the individual school board level.

British Columbia

Just about every school district in B.C. has at least one local area network (LAN) in operation. There are approximately 1 500 LANs connecting anywhere from four to 30 work stations. There is a LAN in each of B.C.'s 375 secondary schools. Ninety-five percent of LANs are Novell. Those that run in a MAC environment use MACJanet or Appletalk.

"There is a LAN in each of B.C.'s 375 secondary schools."

B.C. has the largest number of schools involved in SchoolNet. This is largely due to the existence of the Community Learning Network (CLN), which has been in place for a few years. It was originally a pilot project involving eleven K-12 school districts in the southern interior region of the province. This service offers e-mail, a range of server-based learning facilities and Internet access. The CLN also offers a variety of Gopher

services, and in the fall of 1994 will provide its clients with Mosaic services and First Class server connectivity. The province and the Ministry of Education have made a commitment to expand the CLN to all 1 663 public schools within the next 18 months. In part, this will be achieved through a broader government initiative called the Provincial Learning Network (PLNet), which will interconnect all public libraries, museums, schools, universities, colleges, public-sector agencies, ministries, and Crown corporations. There are approximately 3 000 students and teachers on this network. An estimated 18 000 to 20 000 students and teachers have access to either local e-mail or Gateway mail.

"Last year Apple & IBM sold "$30–million worth of hardware to B.C. schools, representing approximately 12 000 work stations."

There is no current formal survey of computers in B.C. schools. However, based on the hardware purchasing standing offers, through which a majority of the computers are bought, estimations can be made. There are 530 000 K-12 students in B.C., and there are approximately 77 000 to 80 000 computers in B.C. schools, giving a ratio of approximately one computer to every 15 students. To get an idea of how many of these computers were recently bought, note that last year Apple and IBM sold $30-million worth of hardware to B.C. schools, representing approximately 12 000 work stations.

The B.C. government has tried to make it easier for schools to buy informatics equipment and software by redefining the terms under which money can be spent to include not only textbooks but information sources such as on-line databases, software and information technology. At the end of July, 1994, the Minister of Education announced a revision to learning resource funding. School districts may now spend up to 20% of their annual learning resource allocation on computer hardware. This translates into an additional $5 million per year that may be used for this purpose.

Recently announced policy directions outline a new emphasis on information technology for all students in Grades 4-10. Students in Grades 11 and 12 will also have a number of course options related to information technology and associated career paths.

"The impact of the GEMS program has been an improved computer-to-student ratio in Ontario, from one to 39 in 1984 to one to 11 in 1992."

Ontario

In Ontario, a funding initiative called "Computers Across the Curriculum" has been established to address the critical issue of integrating computers into the school system. In 1983, Ontario established functional requirements for grant-eligible microcomputers (GEMS). These specifications were updated in 1992 to reflect the changing technology. GEMS machines must have 16- or 32-bit architecture, be capable of being networked and be multi-tasking. Less powerful machines that do not support networking, or a common software portability environment sold by

GEMS-approved vendors, are also eligible for grants. However, these computers would be at a disadvantage when it comes time to connect to the Information Highway. Boards can obtain up to 95% of the price of a GEMS system through the Recognized Extraordinary Expenditure Grant. On average, the provincial share of this funding amounts to 75% of the total money spent by boards. The impact of this program has been an improved computer-to-student ratio in Ontario, from one to 39 in 1984 to one to 11 in 1992.

The computer to student ratio in 1992 for all Ontario schools was one to 11. In comparison, the ratio of GEMS-funded computers to student was one to 17. The overall computer-to-student ratio for secondary schools is better, at one computer for every nine students, while the ratio for GEMS-funded computers was one to 12. The computer-to-student ratio for elementary schools was one for every 13 students. The ratio of GEMS-funded computers was one for every 22 students.

"Ontario Education and Training Minister Dave Cooke, recently announced that $5 million in government funding is being provided to enable all school boards, including those in remote areas, to link into existing computer networks."

During 1983 to 1987, the Ministry committed over $20 million to the development of high-quality educational software geared to the specific needs of the Ontario curriculum. The Ontario Educational Software Service, housed at TVOntario, distributes this software free of charge to school boards, and it may be legally duplicated throughout the educational system in Ontario at no extra cost. In addition to this program, the Software Acquisition Program has been set up to help schools establish software libraries.

Ontario policy requires boards of education to establish and maintain a base of computers and software, so that all students have the opportunity to acquire and maintain computer skills by using a variety of computer applications in all subject areas and in all grades. Their guidelines recommend a minimum of 2.5 hours per week of computer use, throughout a child's education (Junior Kindergarten to OAC).

Education and Training Minister Dave Cooke, recently announced that $5 million in government funding is being provided to enable all school boards, including those in remote areas, to link into existing computer networks. This "Education Highway" will enable teachers to communicate province-wide, as well as obtain an abundance of worldwide information through the Internet. Students will also be able to perform worldwide information searches and chat with students within the province and beyond.

Quebec

Quebec has a computer-to-student ratio of approximately one to 20. As is the situation in most provinces, a large percentage of computers are not current technology. According to a report "Le parc de micro-ordinateurs utilisés dans l'enseignement en 1992-1993,"[2] 26% of the computers have less than 512KB of internal memory; 66% have no hard drives; 66% do not have a high-resolution colour monitor (VGA or super-VGA); only 8% of schools have a CD-ROM player (500 units in total); and only 5.7% of schools have computers with a sound card.

"A survey of computers in Quebec schools revealed that: 26% of the computers have less than 512KB of internal memory; 66% have no hard drives; 66% do not have a high-resolution colour monitor (VGA or super-VGA); only 8% of schools have a CD-ROM player (500 units in total); and only 5.7% of schools have computers with a sound card."

In 1990-91, the Quebec school boards and the Ministère de l'Éducation du Québec (MEQ) spent $4.8 million on the acquisition of educational software, representing the purchase of approximately 700 software titles for the 1.25 million students of the 2 600 schools in the province. In 1993-94, the money spent on software acquisition had dropped approximately 33% from the 1990-91 figure, to $3.2 million.

MEQ has 45 regional centres that support the use of technology in the schools. Centrally, a number of programs are in place including support for software development, software evaluation, teacher training, educational innovation and the use of technology in the school.

A number of initiatives have been undertaken in Quebec with the goal of integrating C&IT/multimedia in schools, including the following:

- In 1992, "la Direction des technologies éducatives" of the MEQ and the Conseil de l'industrie du logiciel éducatif et de formation du Québec (CILEF) set up a network of education and training software development, in collaboration with Industry Canada, Federal Office of Regional Development - Quebec (FORD-Q), ministère de l'Industrie du Commerce et de la Technologie (CICST), Centre de promotion du logiciel québécois (CPLQ), CITEC and Inno-Centre.

- Recently, the "Centre national de documentation pédagogique de France" (CNDP) and MEQ initiated a collaborative France-Quebec project to set up a network to exchange information on multimedia teaching and training.[3]

- MEQ's "Direction des technologies éducatives" and a France-Canada Group on tele-learning launched a project called "l'école informatisée clé en main," which will work on the integration of C&IT in the day-to-day activities of a secondary school. They would like to develop a model that could be easily transferable to

other similar institutions. They will pilot three schools in 1994–95. The project will be done in collaboration with a number of private enterprises, research centres and educational associations.[4]

New Brunswick

"As of 1996, computer skills must be mastered in order to graduate from a New Brunswick high school or community college."

Recently, New Brunswick Premier Frank McKenna announced computer literacy requirements for N.B. graduates. As of 1996, computer skills must be mastered in order to graduate from a New Brunswick high school or community college. To be considered computer-literate, students will have to understand the capabilities of a computer, use a variety of software, and use the computer to communicate with other technology. This is the first mandated requirement in Canada.

Another project is "Technology Across the Curriculum - UNITE" (Using Networks to Integrate Technology with Education). The emphasis is on Grades 4, 5 and 6. The classrooms of these grades have been cabled into advanced LANs in 160 schools across the province. The Ministry supplied each school with 13 computers (12 for the students and one for the teacher) and the rights to NOVELL for 50 stations. In the second phase, networked CD-ROM technology will be implemented to support research. In Phase 3, the schools' telecommunications capabilities will be enhanced through access to Internet, and all of the schools' LANs will be linked through a WAN. The current schedule calls for half of the 400 schools in New Brunswick to be tied into national and international computer networks by the end of 1994. Twelve schools are involved in the official SchoolNet pilot project, and eight schools are part of the National Network of Learning run out of North York.

The ratio of computers to student is one to 15 across K-12. The ratio is slightly higher for elementary students, and lower for secondary.

Nova Scotia

According to the last official survey (February 1993), there were 86 070 computers and peripherals in Nova Scotia schools, of which 64% were not considered to be current technology (386 and up). The ratios of computers to student were as follows:

- Elementary - 1:30
- Junior High - 1:20
- Secondary - 1:16

Ratios for current technology (386 and up/Mac LC or later) were as follows:

- Elementary - 1:164
- Junior High - 1:61
- Secondary - 1:38

Eighty-five of the 492 schools in Nova Scotia have Internet accounts. NSTN offered five accounts for each of the 22 school districts.

In 1993, Nova Scotia introduced the $1.5-million Technology Innovation Grant Program, which is provided to help district school boards to acquire information technology. In 1994, an additional $1 million will be available to boards.

Yukon

There are 1 400 computers in the Yukon's 29 schools. This represents approximately one computer for every five students. About one third of the computers are two years old or less, another third are over three years old and the rest are very old machines (e.g. Apple IIs). The possibility of setting up a BBS for the Yukon is being investigated.

NOTES TO SECTION IV

[1] TeleEducation NB, "*TeleEducation NB Report 1994.*"

[2] Le parc de micro-ordinateurs utilisés dans l'enseignement en 1992-93, Paul Danvoye, September 22, 1993, direction des technologies et des ressources éducatives, document DTRE-93-002.

[3] Industrie Canada. La direction des industries de communications et de services d'Industrie Canada. *Le multimédia au Québec : un tour d'horizon - version préliminaire 2.1*. Québec : juin 1994.

[4] Comité d'orientation québecois. *Projet de recherche-action - L'école informatisée "clé en main."* April 1994.

V. ISSUES RELATED TO THE DEPLOYMENT OF C&IT IN SCHOOLS

This section will identify and examine a number of significant issues related to the successful deployment of C&IT in schools.

STAKEHOLDERS' VIEW

A number of critics and authors have commented on the slow adoption rate of C&IT in schools. A recent survey of school administrators, non-teaching staff, teachers, students and parents, was conducted by the Ministère de l'Éducation du Quebec.[1] Respondents were asked questions on their use of C&IT, their attitudes toward the technology, and their wishes. In particular, they were asked why the province's teachers were slow in using C&IT in their classrooms. Their responses can be summarized in nine points:

"There is a lack of information on the capabilities of C&IT, which in turn leads to questions concerning its usefulness, particularly where software is concerned."

1. There is a lack of information on the capabilities of C&IT, which in turn leads to questions concerning its usefulness, particularly where software is concerned.

2. Teachers are not consulted when hardware and software are purchased.

3. Teachers' workloads, number of computers, their performance and location are not conducive to the use of C&IT in day-to-day tasks. Students complain that they do not have access to the computers, as they are situated in labs reserved for students taking introduction to computer sciences and other similar courses.

4. Software packages are not always user friendly and there are no standards for user interfaces. Applications used are not integrated, and transfer of data between applications is often complicated. Networks are complex and not always reliable.

5. There is a lack of training related to the use of C&IT. When training is available, it is not included in the workload.

6. Training is usually done for specific software packages, which does not provide enough knowledge for teachers to become autonomous in a new C&IT environment. For example, training does not address access menus or navigational tools.

7. There is no local support to service the computers and networks, to take care of network management functions, or to address problems with software packages.

8. Teachers feel isolated in their own area of expertise and do not have access to other teachers to help them with the acquisition of educational software.

9. There is a perceived lack of planning or long-term vision in the integration of C&IT in schools. Local initiatives focus on the introduction of new software instead of on the process of change in education to best use C&IT.

"There is a perceived lack of planning or long-term vision in the integration of C&IT in schools. Local initiatives focus on the introduction of new software instead of on the process of change in education to best use C&IT."

Even though the survey was carried out with a relatively small sample, it seems to represent a snapshot of attitudes and problems related to C&IT in education. Similar comments were made by other stakeholders interviewed in Canada and the U.S.

EDUCATORS' INVOLVEMENT IN C&IT

These comments point toward a holistic approach to C&IT in education. This does not necessarily mean a "centralized-big-budget-lots-of-resources-committee-based" project. In fact, as discussed earlier, the most successful means of implementing C&IT appears to be through local initiatives. The local school principal with a vision, who is willing to make tradeoffs, and bend the rules through "creative insubordination,"[2] and who has the ability to capture the interest of the community and the support of the teachers, staff and students, is in the best position to make that change. It would be very difficult to clone such an individual. It is also difficult to maintain initiatives without such an individual leading the process. As Lewis J. Perelman notes, "once the leader retires or moves on or is simply overwhelmed by persistent political opposition, or the inevitable budget crunch, the situation usually reverts to *normal*."[3]

While business and governments have been asked to improve efficiency, education still remains relatively untouched. In fact, according to Statistics Canada, there were more teachers per student in 1990 than 10 years earlier.[4] This number includes all teaching staff, including guidance counsellors and other specialists addressing the educational needs of

students. Some critics argue that teaching is one of the only professions in which a person who taught 100 years ago would be able to operate in today's environment. The blackboard and the chalk are still the basic tools used. As mentioned above, educators have limited training in C&IT, and most are not aware of how the technology can be used.

Since principals and superintendents are often at the centre of the successful introduction of C&IT in schools, it is important to ensure that these individuals understand how technology can be successfully introduced, and how they can develop strategies to take full advantage of its capabilities. They must understand that C&IT is not a subject to be taught, but a tool to be used by both teachers and students as part of the learning process. It could be beneficial to train principals and superintendents on how to take full advantage of the potential of C&IT. A three-day intensive program on how to successfully manage technology in a school environment could cost approximately $22 million for salaries and tuition (see Section VI).

"A three-day intensive program on how to successfully manage technology in a school environment could cost approximately $22 million for salaries and tuition."

Teachers' involvement is crucial. They must be central to the whole process of technology deployment. According to a national survey of teachers in the U.S. done by the Center for Technology in Education (CTE),[5] teachers who are resourceful and motivated are an elite group, typically "experienced and highly educated." Nearly half of the surveyed group had used a computer for more than nine years. They are self-taught in telecommunications and have access to a computer at home. CTE estimated that teachers with that experience and motivation comprise no more than two or three percent of the teaching population.

Fragmentation of responsibilities makes the exchange of information between educators difficult. Many "pilot projects" try to re-create the same tests that have been carried-out in other jurisdictions. This may be because it is more politically justifiable to get additional funding for a field trial than it is to just introduce technology in schools as part of regular activities. One cannot blame educators with initiative for trying to appropriate funding for their schools.

"Teachers' involvement is crucial. They must be central to the whole process of technology deployment."

TEACHER TRAINING AND ACCEPTANCE OF C&IT

Teacher training has been recognized as a major issue in the implementation of C&IT in classrooms. Teachers must be shown how to effectively implement new technology; how to use it to enhance their courses; and how technology can be used to help them accomplish their other educational goals. A number of sources indicated that the teaching

"establishment" was reluctant to use the tools associated with the Information Highway and move away from traditional teaching methods. Researchers maintain that "teachers are more likely to become committed to the technology implementation if they believe that it will help them achieve other important educational goals." A study carried out by Eric Hanushek determined that teacher effectiveness in the classroom is the most important factor in the success of students.[6]

"This raises the question as to where the training for educators should be directed: to existing educators; or to new graduates of education faculties."

According to Statistics Canada, 33.6% of families with children under the age of 18 own a computer.[7] In this context, it is not surprising that students often know more about C&IT than the teachers. It has been reported to us that this situation can be very difficult for some teachers to handle. Having to ask a 10-year-old how to perform a function on a computer can be very humbling for a veteran teacher and difficult to accept. Traditionally, teachers have known so much more than their students that they could field any question. However, in the area of C&IT, many teachers may not have the knowledge required to handle questions with the same ease. The varying level of knowledge and abilities among students also creates a problem in classroom teaching. A significant percentage of educators are approaching retirement age. Within the next 10 years, approximately one third will be of retirement age. This raises the question as to where the training for educators should be directed: to existing educators; or to new graduates of education faculties.

"If all of the more than 300 000 primary and secondary educators in Canada took two weeks for C&IT training it would be a 12 000 person-year effort, representing a cost of $550 million in wages."

In one school board, students reported that they could not save on diskette the findings of searches they carried out on CD-ROM. Students were asked to print their results, as the teachers responsible did not want to run the risk of infecting the network with viruses that may be imported through the students' diskettes. Students have to re-input the information in their word processors to prepare their papers. Technology is widely available for networks to automatically scan diskettes and disinfect them if necessary. Some teachers do not accept research with sources outside of the school, especially on-line. This exemplifies the lack of appreciation for the current use of technology outside the public educational system, and deters exploration, resourcefulness and analysis of information from diverse sources.

Apart from training teachers on the technology, another major issue is the need to teach them how C&IT can be used to stimulate learning. Most of the more than 300 000 primary and secondary educators in Canada would require C&IT training. If this could be done in two weeks, it would be a 12 000 person-year effort. The average annual salary for educators is approximately $47 500. This training effort would represent a cost of $550 million in wages for teachers (see Section VI). However, training does not replace experience, and it would therefore require a significantly longer

period of time to be effective. In the year prior to the opening of River Oaks Public School, a retreat and a series of planning and technology training activities were organized during after-school hours.

One potential approach is to train teacher-specialists in each school. NASA offers an intensive summer training program in information technology for teachers. The month-long course covers the basics as well as advanced topics, including the use of computers to conduct science experiments in classrooms. If each school sent one teacher on this course, assuming a tuition of $2 000 per participant and the teacher's salary for this period, the total cost would be close to $100 million (see Section VI).

Another less costly way to combat the training problem is to formally train several students to become the "experts" and systematically diffuse their knowledge to others.[8]

INADEQUATE TECHNOLOGY

Overall, very little research and development (R&D) has gone toward developing tools to improve the effectiveness of the educational process worldwide. Little work has been done on finding tools that can be used to speed up the process of learning, improve the results and reduce cost. According to Lewis J. Perelman, in 1989 the U.S. federal government devoted approximately US$216 million toward R&D in high-tech teaching, learning, and innovative instruction.[9] He also estimates that in the U.S., the annual amount spent on research related to learning is less than US$50 per student.

"The reality educators are facing is that students will have spent more time in front of the television than in school by the time they graduate from high school."

The reality educators are facing is that students will have spent more time in front of the television than in school by the time they graduate from high school. Video games, television and movies offer a stimulating environment that the present educational system cannot match. It is therefore not surprising that boredom and lack of relevance are the most cited reasons for dropping out.

A current trend in trying to solve the problem of the lack of C&IT in schools is to encourage corporations and government to donate their superfluous computers, software and other equipment to schools. However, as corporations generally dispose of equipment that is old and no longer useful to them, the gift may ultimately be very costly to the school in terms of dollars and time. Often, the equipment needs new components such as a hard disk, or memory needs to be upgraded, and there is no guarantee that it will function over the long haul, especially in the brutal

school environment. It may also be necessary to have personnel spend time fixing and integrating the equipment into to their environment. The corporations can deduct the value of the equipment for tax purposes, with the result that society pays by providing the tax write-off, while getting old hardware and software. However, this may be the only way schools can acquire any form of technology.

Many schools have introduced C&IT through special funding and special projects. These are often of a set duration, and include equipment loans and free communications lines. At the end of the trial period, schools are faced with a major expenditure to purchase the quipment and/or to start paying the communications charges. In many cases, they cannot afford the system tested in the pilot project and must revert back to the "old ways." This is demoralizing for both teachers and students, when the excitement forged by their experience must become a memory. Students face a similar problem when they transfer or graduate from an "innovative" school to a regular school.

One of the most important considerations regarding the widespread introduction of C&IT in schools is the need to keep the infrastructure current. Computer performance is doubling every 18 months (or generation), the transmission capacity of networks is doubling every two years, and information available to us is doubling every few years. The introduction of new versions of software makes machines that are only a few years old, obsolete. Wear and tear on the equipment, especially in a school environment, is also high. To keep up, we must continuously upgrade the equipment and remain within two hardware and software generations of the newest available system.

Currently, most schools have a limited capacity to communicate with the outside, including telephones. There are few lines connecting the schools' phone systems to the outside, and few schools have data lines and modems, fax machines, answering machines, LANs, etc. Today's LANs may also require upgrading to meet the capabilities of the computers purchased over the next three to four years, but the cost of such "upgraded" networks and the lack of interfaces does not make it practical now. Many technological alternatives currently under development could be available by that time. Market forces make it very difficult to decide the best alternative for schools. Technical alternatives include: FDDI, CDDI, ISOEnet, Switched Ethernet and ATM. The new systems should require isochronicity to permit real-time voice and video communications to the terminal, and enough bandwidth to support real-time multimedia communications.

We recognize that technology may help in the provision of educational services for students in rural areas. However, cost, availability and quality of communication links in those areas are serious problems that may have a negative impact on the ability of those students to tap into new technologies. Free local access to communication networks such as Internet, using the Freenet model, is practically impossible in rural areas. The problem is compounded in very remote areas, such as the Northwest Territories and the Yukon, where line quality may not permit transmissions at high speed over the phone network.

We estimate the required expenditure for C&IT to be approximately $5 billion a year to install and maintain hardware and software."

As indicated in our case study (see Section VI), we estimate the required expenditure for C&IT to be approximately $5 billion a year to install and maintain hardware and software in all K-12 schools in Canada. Without this, it will be virtually impossible for schools to remain capable of educating our students at the level required by industry. At this time, the proportion of budget that is spent on C&IT in education is difficult to determine, as such statistics are not available in Canada.

Keeping hardware and software current would provide educators with the ability to use computers in new ways in the future. Some of the new C&IT concepts that could be used in education include: artificial intelligence (e.g. ask an expert), understanding natural languages (e.g. computer correcting an essay), use of fuzzy logic (e.g. identification of trends in student learning), simulation of complex systems (e.g. scientific experimentation), multimedia (e.g. textbooks with video clips and sound annotations), video-conferencing (e.g. joint projects with students in other sites), multi-tasking (e.g. desktop video-conferencing while carrying out data acquisition for a joint experiment), voice recognition (e.g. practice for speech therapy), handwriting recognition (e.g. practice for younger students to learn writing skills), and virtual reality (e.g. virtual classrooms).

"Contrary to popular belief, the use of technology in the classroom does not guarantee better results for students... how the technology is implemented and used plays a crucial role in providing those results."

EFFICIENT USES OF TECHNOLOGY

Contrary to popular belief, the use of technology in the classroom does not guarantee better results for students. Many factors, such as how the technology is implemented and used, play a crucial role in providing those results. Technology should be studied and adapted to take full advantage of its capabilities, and implementers should look at new ways of teaching using technology. Researchers in the field of education have argued that technology will have less impact on the quality of learning if it is only used to support traditional modes of teaching and learning, and that utilization of technology resources to their potential requires restructuring the physical space, curriculum, and scheduling arrangements in school. A

recent survey of teachers, carried out by the Education Technology Centre (ETC), involved in a C&IT deployment project indicated that classroom-based computer centres with printers is the preferred option for increasing the effectiveness of the use of computers.

Currently, many schools are not using technologies such as video and computers to their full potential. CIRCIT, an Australian C&IT research centre, reported that: "Putting a talking head on a video-conference link is boring precisely because it simply uses the old method of teacher-focussed instruction with another form of delivery."[10]

In tele-education, planning on how to properly use the technology is especially critical. One of the most important aspects is to recognize that certain technology must be used for certain tasks. If you are teaching music at a distance, the lack of sound (and, potentially, images) can be a major problem for the teacher and the students. The sound and image quality can also be very important. In the previous example, if the sound is highly compressed to minimize bandwidth, the teacher and students may not be able to get the nuances of the technique.

Course preparation is also a key element in the success of tele-education. A representative of TeleEducation NB offers this advice: "Distance education forces teachers to do all those things they ought to do, things such as prepare the whole course ahead of time, plan each class, consider which material should be presented in which ways, approach the lesson from the point of view of the learners, and so on."[11] He goes on to suggest that only the better teachers make a successful transition from classroom to distance, and therefore the course tends to be of better quality. A tighter course is also better for students, as everyone knows the schedules and assignments.

Through networks, education is becoming competitive. Canadian students can get degrees from foreign institutions without ever setting foot on the campus. While Canadian schools argue over course accreditation, jurisdiction and funding, foreign institutions are actually teaching our citizens without worrying about such problems. Canadian schools with national or international stature could provide diplomas and degrees outside their traditional borders. Such a system could provide an opportunity for our schools to attract new students and funding, while furthering their reputation and recognition abroad.

SOME OBSERVED BENEFITS OF C&IT

Pilot projects and lead schools have provided some valuable information on how to introduce technology, on what impact it has on learning. Educators surveyed by the Educational Technology Centre of British Columbia reported that they observed enthusiasm and joy for using computers, even after two to three years of use. This was described not as the type of excitement that is generated when playing a game, but more of a deep-rooted sense of pleasure and interest.[11] The computers encouraged social interaction and co-operation in problem-solving techniques. Ordinary students have a chance to excel, and many ordinary students did many extraordinary projects with the help of computer-related technologies. Some teachers reported that they had underestimated what children could do on the computer, and that they were amazed by their accomplishments.

"The computers encouraged social interaction and co-operation in problem-solving techniques. Ordinary students have a chance to excel, and many ordinary students did many extraordinary projects with the help of computer-related technologies."

NOTES TO SECTION V

[1] Johanne Guidotti, *Rapport d'entrevues sur l'intégration des nouvelles technologies aux activités des écoles secondaires.*

[2] "The Good Principal: A Tradition Breaker," *The New York Times* (Feb. 21, 1990).

[3] Lewis J. Perelman, *School's Out ...*

[4] Statistics Canada & CMEC, *A Statistical Portrait of Elementary and Secondary Education in Canada*, (July 1992).

[5] Margaret Honey and Andrés Henriquez, *Telecommunications and K-12 Educators: Findings from a National Survey*, (New York: Center for Technology in Education, Bank Street College of Education, 1993).

[6] Eric A. Hanushek, "The Impact of Differential Expenditures on School Performance," *Educational Researcher* (May 1989).

[7] Statistics Canada, Catalogue 13-218.

[8] Austin Clarkson, J. Durlak and K. Pegley, *Creative Applications for Multi-Sensory...*

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[10] "Learning Networks for the 21st Century: Conference Issues." *CIRCIT Newsletter 1994.*

[11] "It's a Whole New Way of Teaching," *New Directions New Approaches*, New Brunswick Advanced Education and Labour, (October 1993).

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VI. BACK OF THE ENVELOPE COST CALCULATIONS

BACKGROUND

One of the most important aspects of the use of the Information Highway in education is to determine how much it will cost. This section provides "back of the envelope" calculations for different scenarios. It is improbable that schools will be connected to the Information Highway all at once, and thus interim steps should be envisaged. The calculations provided use only the most current numbers available. The results are broad estimates only, and as such should not be used for budgetary purposes. Accurate figures would require a substantial effort to gather information and analysis to determine the exact requirements for a given situation. Figures will also vary by region, as the numbers used are averages. Technological solutions presented here may not be appropriate in all cases, and some services may not be available in some areas.

As discussed earlier, numbers needed to evaluate the cost of different options, particularly with regard to C&IT, are difficult to obtain. This is mostly due to the distributed responsibility for education. Numbers are available centrally in some provinces, while in others, individual schools gather this information. Other general statistical information, such as enrolment, number of schools and number of teachers, is available from reliable sources such as Statistics Canada. In the preparation of this section, the aforementioned statistics were used to estimate the total number of classrooms in the country and the average class size. Most of the figures quoted are derived from Statistics Canada 1993-94 estimates.

Along with statistical data, some estimates are based on the best assumptions of those involved. Source information is included for all figures and estimates.

BASIC STATISTICS

Number of students

According to Statistics Canada, there are **5 360 900 students** in Canadian primary and secondary schools.

Number of teachers

Statistics Canada reports that **300 797 persons** are teaching full-time in Canadian K-12 schools. This number also includes qualified teachers that are in non-teaching positions, such as specialists, school librarians and school principals. We have not been able to get the exact number of "classroom" teachers in Canada, as no organization seems to gather such detailed information.

Number of schools

The total number of Canadian K-12 schools is **16 231 schools**. This number includes both public and private schools.

Average school size

Simple math tells us that the average number of students per school is **330 students** (students ÷ schools).

Average class size

Following discussions with such organizations as the Canadian Teachers' Federation and Ministries of Education, we have estimated an average class size of **26 students**. Most of the information gathered relates to the ratio of students to educator. This did not give us the number of students per classroom, as the non-teaching educators are included in the ratio. Therefore, we could not use these numbers to calculate the cost of C&IT.

Determining the number of classrooms

We must determine the number of classrooms in the country, as reaching the classrooms is the first step in reaching students and teachers. As previously mentioned, there are 16 231 K-12 schools and 5 360 900 K–12 students in the country. Using our estimate of the average class size (26 students), we determined that there are **206 188 elementary and secondary classrooms** in Canada.

The cost of telephone lines

The cost of telephone lines is not consistent across the country or even within one province. This is due to tariff differences that take into consideration the local calling area and the internal rate of return of the phone company. Schools pay the tariff set for business lines or trunks. Some schools have a local switch or PBX equipment, while others are

served through key systems and Centrex services. All these factors have a direct influence on the cost of a phone line. As this number is not known, through discussions with Stentor we determined an average price that would be representative. We estimated that the average cost of a business line is **$45 per month, with installation charges of $100.**

The cost of ISDN lines

Basic Rate ISDN lines (2B+D) tariffs for monthly and installation charges were estimated at twice the regular telephone rate. This is based on the telephone companies' philosophy that ISDN lines are worth twice as much as regular lines. Therefore, the average cost of an ISDN line is **$90 per month, with $200 for installation.**

The cost of broadband services

There are no broadband (>1.5Mbps) switched services tariffs in Canada at the present time. Individual point-to-point broadband lines may be leased from a common carrier, and organizations may install their own broadband switches to provide switched services. An affiliate of BC Tel is offering a non-tariff service based on this principle.

Some states in the U.S. have negotiated special rates for broadband services. These rates were approved by the local Public Utilities Commissions. One of the most aggressive states in this respect is North Carolina. Schools have been offered a tariff for the local portion to connect to the state's Asynchronous Transfer Mode (ATM) switches through a SONET 155Mbps (OC-3) or 622Mbps (OC-12) links. Schools will pay US$1 025/month (C$1 365) plus a US$1 000 (C$1 330) one-time installation charge. Schools are also responsible for the ATM terminal(s) and other terminal equipment, such as a video-conferencing system. Local usage charges (Intra-LATA) of US$28.00 (C$37.25) per Gigacell (unit of measure for ATM networks, where one hour of video-conference at 45Mbps is equal to .422Gigacell). Long-distance (Inter-LATA) charges, which are not part of the tariff, must be provided by the state, and therefore must be added to the total cost of communication. For five hours of video-conference a day over the 180 days of the school year, this translates into C$15 000 per year or C$1 500 per month over the 10 school months. If the Inter-LATA charges were on average double the Intra-LATA or C$74.50 per Gigacell, and half of the use was Inter-LATA, another C$1 500 per month would be needed.

It is extremely difficult to estimate the cost of broadband services, even based on the U.S. tariffs, as the quantity and mix (i.e. voice, data, image and video) of traffic, origination and destination point, and distance all have a bearing on the total cost of communications. Therefore, we do not venture an estimate for this type of communication link.

LAN connection to the desktop

Providing an internal communication network (LAN) to link all terminals is an important step in giving all students and teachers access to the services and information available on the Information Highway. The Gartner Group, a well respected C&IT consulting company, has published a methodology to estimate the cost of providing a LAN connection. The numbers provided by the company relate directly to corporations' costs for hardware, software and support services. Businesses also require, generally, more software tools and larger and more powerful servers. Schools are often provided with some technology at lower cost, or it is bundled with the terminals purchased. For this reason, two scenarios are presented: the first uses Gartner's numbers, and the second uses estimated numbers for schools.

	Gartner Group	Estimate for Schools
Cabling	$ 300	$225
Adapter Card	500	75
Network O/S	200	0
File Server	600	100
Hub Port	375	75
Bridge/Router	550	40
Connectivity Software	465	100
Management and Utilities	165	125
Installation	325	245
TOTAL	**$ 3 480**	**$ 985**

Table 2

CALCULATIONS

Telephone line in each school

The following represents the cost of providing every school with one additional telephone line used to access a local data communication network.

	Recurring (monthly)	One-time	Yearly
Monthly charge	$730 395		$8 764 740
Installation charge @ $100		$1 623 100	
Modem purchase @ $250		$4 057 750	
TOTAL		**$5 680 850**	**$8 764 740**

Table 3

Telephone line in each classroom

These calculations represent the cost of providing one telephone line in every classroom used to access a local data communication network, as a voice line to allow students to reach the teacher by phone to get information for school projects.

	Recurring (monthly)	One-time	Yearly
Monthly charge	$9 278 460		$111 341 520
Installation charge @ $100		$20 618 800	
Modem purchase @ $250		$51 547 000	
TOTAL		**$72 165 800**	**$111 341 520**

Table 4

ISDN line in each school

The following is the cost of providing one ISDN line in every school used to connect a school LAN to access a local data communication network. California is in the process of implementing such a strategy at the state level, in collaboration with the local telecom carrier.

	Recurring (monthly)	One-time	Yearly
Monthly charge (est. at two times the phone rate)	$1 460 790		$17 529 480
Installation charge @ $200		$3 246 200	
Terminal adaptor/bridge purchase @ $2 500		$40 577 500	
TOTAL		**$43 823 700**	**$17 529 480**

Table 5

The following are the cost estimates for the purchase of various C&IT equipment:

TV and VCR in each classroom

	Recurring (monthly)	One-time	Yearly
TV & VCR Purchase @ $ 1 000		$206 188 000	
TOTAL		**$206 188 000**	**$0**

Table 6

Computer for each teacher

	Recurring (monthly)	One-time	Yearly
Computer Purchase @ $3 500		$1 052 789 500	
Productivity software suite @ $ 1 500		$451 195 500	
TOTAL		**$1 503 985 000**	**$0**

Table 7

Computer for each student

	Recurring (monthly)	One-time	Yearly
Computer Purchase @ $3 500		$18 763 150 000	
Education software suite @ $1 500		$8 041 350 000	
TOTAL		**$26 804 500 000**	**$0**

Table 8

Cable TV extended to every classroom

As discussed earlier, the CCTA is planning to install a cable TV connection to every school in Canada in the areas where participating cable TV operators provide service. To extend the service to the classrooms where they are needed, an additional cost would be incurred by the schools. We have estimated $225 per connection (similar to the LAN cabling cost), and assume that every school in Canada would have access to cable.

Cost per connection	$225
Number of classrooms	206 188
TOTAL (one-time)	**$46 392 300**

Table 9

Video-conferencing in the school

One aspect of communications discussed in this paper is classroom video-conferencing. Indeed, video communications are an obvious application of broadband services, and are likely to be the driving force on the Information Highway. Schools that have dedicated systems installed in classrooms have spent on average $65 000 to $80 000, depending on the equipment and options chosen. Other less sophisticated "roll-about" systems used for business video-conferencing can be used, but may not be as effective in a classroom environment.

The following table examines the cost of installing one dedicated video-conferencing system in every school in Canada to provide an access point to the students and the community. The average cost per school is estimated at $75 000. The following estimate is for hardware only, and does not include network connection and usage charges, as they are traffic, distance and bandwidth sensitive and therefore difficult to estimate.

Cost of video-conferencing equipment	$75 000
Number of classrooms (one per school)	16 231
TOTAL (one-time)	**$1 217 325 000**

Table 10

Voice mail for every classroom

Some schools have successfully deployed voice mail to provide a means of communication between teachers and the home. Voice mail services can be purchased from phone companies or other providers at a cost of approximately $18 per month per mailbox for Centrex-type telephone service. Some school telephone systems can be upgraded to provide such service, but the cost is difficult to estimate as the age, size, make and sophistication of the phone system are all contributing factors. For this reason, we have used $18 per mailbox per month and a one-time $20 activation charge as a budgetary number for the calculations.

	Recurring (monthly)	One-time	Yearly
Voice mailboxes for each classroom	$3 711 384	$4 123 760	$44 536 608
TOTAL		**$4 123 760**	**$44 536 608**

Table 11

CASE STUDY FOR SCHOOL C&IT

Using the estimates noted above, we can examine the following case. The case involves supplying one computer (including software) for every teacher, and one for every three students. Also included are a LAN connection to the desktop; a laser printer in every classroom; two colour printers in every school; an ISDN line to connect LANs locally; and $1 500 of other equipment for every classroom. ISDN lines are used in this scenario, as this is the fastest switched service widely available in Canada, albeit only in major centres. This service could be deployed more easily than any other broadband offering as tariffs are in place and technology is commercially available.

	One-time	Recurring (monthly)	Total 3 years	Amortized 3 years
Computers for teachers (incl. software)	$ 1 503 985 000		$1 503 985 000	$501 328 333
Computers for students (incl. software) (ratio 1:3)	8 934 833 333		8 934 833 333	2 978 277 778
LAN to desk ($985)	1 760 162 167		1 760 162 167	586 720 722
Laser printers (one per classroom)	412 376 923		412 376 923	137 458 974
Colour printers (one per classroom)	162 310 000		162 310 000	54 103 333
Other quipment, $1 500 / classroom	309 282 692		309 282 692	103 094 231
ISDN line in every school + routers	43 823 700	1 460 790	96 412 140	32 137 380
TOTAL	**$13 126 773 815**	**$1 460 790**	**$13 179 362 255**	**$4 393 120 752**

Table 12

In the above scenario, it would cost more than $13 billion over a period of three years, or more than $4 billion per year to provide this level of technology in the classroom. This would be a very bold initiative, and would not address "soft" costs such as training and technology integration into the curriculum. Other "extras" or network charges could increase the total cost by a further $500 million.

Cost recovery - offset

In this section we examine direct offsets to the cost of providing a high level of C&IT in public schools. Students in post-secondary education are asked to pay a fee for the use of C&IT resources, over and above the basic fees. K-12 students in the public system are sometimes asked to pay for additional or extra-curricular activities. Costs could be offset by asking each K-12 student to pay $20/month for C&IT resources and by selling the school computers after three years for $500 each. The charge for students does not indicate that we advocate this solution, but is presented only as an option for funding C&IT in schools.

	Per Year	Over 3 years
COST:		
Total equipment and lines	$4 393 120 752	$13 179 362 255
REVENUES:		
Student payments	$1 072 180 000	$3 216 540 000
Sale of computers	$347 960 611	$1 043 881 833
NET COST	**$2 972 980 141**	**$8 918 940 422**

Table 13

Cost per student

Once the costs have been spread over three years, as indicated above, the net cost per student for C&IT can be estimated by dividing the annual cost by the number of students.

Annual cost ÷ Number of students = Average cost per student
$2 956 911 451 ÷ 5 360 900 = $551.57 per student

To put this in perspective, the average cost per student for the C&IT system proposed in the case study, $552, represents less than one tenth of the average amount school boards spent per student in 1990, which was estimated at $6 134.

TRAINING THE EDUCATORS

Training the educators has been identified as a major requirement to provide them with a better understanding of how C&IT can help in the process of learning. We propose that basic efforts be made to train the educators. Salary costs are based on a 260-workday year that may not be appropriate for all educators, since it depends on individual labour contracts. Three scenarios are examined.

Basic technology management for principals

A three-day intensive course could be provided to train the principals of Canadian schools on understanding and managing C&IT and on how to take full advantage of its capabilities in a school environment (without having to understand the details). For the purpose of the cost calculation, a principal's average salary has been estimated at $75 000.

In total it would cost **$22 million** to provide basic training for principals. As they are often the catalysts in the successful deployment of technology in schools, this may be a wise investment.

Number of principals	16 231
Average salary	$75 000
Tuition for the course	$ 500
Number of days of training	3
TOTAL COST	**$22 161 558**
Person years expended	187

Table 14

Training one resource person per school

Another option is to train one resource person in each school, who can share their C&IT knowledge with their colleagues. They could train the other educators in their schools on how C&IT can be used for teaching, and could support the activities of other teachers trying to use C&IT. The cost of a 20-day course, similar to the one offered by NASA to educators through the HPCC program, is estimated in the following table:

Number of teachers (one per school) Average salary Tuition for the course Number of days of training	16 231 $47 500 $2 000 20
TOTAL COST	**$91 767 577**
Person years expended	1 249

Table 15

To send one teacher per school on this program would cost **$92 million** in salaries and tuition alone.

Basic training for all educators in Canada

To provide basic training in C&IT to educators would probably require a two-week effort. This training would only make educators more familiar with technology, and would provide only the basics on how it can be successfully used in the classroom.

Number of educators Average salary Tuition for the course Number of days of training	300 797 $47 500 - 10
TOTAL COST	**$549 532 981**
Person years expended	11 569

Table 16

If all Canadian educators were to attend this 10-day course, the total cost of this project would be nearly **$550 million**, and would require the equivalent in time of close to **12 000 person years**. A $1 000 tuition fee per person would add another **$301 million**, bringing the total cost to **$851 million**.

VII. WHAT DOES THIS ALL MEAN?

The use and deployment of C&IT in education in Canada and in other countries is a complex subject. Our goal has been to present an overview of the situation. Throughout our research, we gathered an impressive amount of documentation, research reports and first-hand experience from educators and those closely related to the field. Although our research is not all encompassing, we feel we have enough information to draw some intelligent conclusions.

ISSUES

- An insufficient amount of equipment (e.g. computers, LANs, modems, TVs, VCRs, video cameras, etc.). found in schools today is capable of connecting to the Information Highway.

- The computer-to-student ratio is inadequate for today's information economy (one computer for 15 to 20 students).

- Computers in schools are generally old and lack the sophistication required to take full advantage of the Information Highway.

- We have not discovered any comprehensive plans to upgrade and increase in size the technological infrastructure of schools to an appropriate level required to take full advantage of technology-assisted learning.

- Technological deployment is often done through pilot projects.

- Generally, educators have a low level of computer literacy.

- A large percentage of educators are approaching retirement age. Within the next 10 years, approximately one third will be of retirement age.

- Some educators lack an appreciation for the current capabilities of C&IT and how it can be used in a school environment.

- Principals and teachers have often been at the centre of successful deployment of C&IT in schools. The local school principal with a vision, who is willing to make trade-offs, bend the rules through "creative insubordination," and who can capture the interest of the community and the support of the teachers, staff and students, is in the best position to make a change.

- The use of technology in the classroom does not guarantee better results for students. Technology should be studied and adapted to take full advantage of its capabilities. Those implementing it should therefore look at new ways of teaching using technology.

- There is a trend in the use of computers in schools. This may be linked to the penetration of computers and teachers' comfort level with the technology. Three levels were identified: teaching about computers; computer-based learning/training; and using computers as a tool in the classroom.

FUNDAMENTAL ELEMENTS

Our research suggests that there are a number of elements that are fundamental to the orderly and successful introduction of C&IT in schools. We observed that the most successful deployment of technology in schools appeared to follow these principles.

- Schools should take advantage of the need for training and lifelong learning by becoming resource centres for continuing education, taking advantage of the technological resources of the institutions. This would provide well-equipped centres for training, and would ensure that technological resources are used more effectively.

- Educators should work closely with industry, research centres and universities to ensure that the programs they develop are practical and relevant to students' future requirements.

- Education should not rely on a single hardware and software architecture, but on a set of technical standards that permit the use of appropriate platforms for the task at hand. The standards should allow for the full exchange of information between platforms through interconnection at the network level. Standards should be set with an eye on the future, ensuring that they can evolve over time to take advantage of new technological developments.

- Technology deployment should be ongoing to ensure that the infrastructure does not fall behind and require a large outlay of funds to catch up.

- Educators should seek the help of corporations and the community to deploy technology. However, it is unrealistic to expect corporations to fund deployment completely, as corporate donations to all causes are estimated at only $450 million per year.

- Collaboration among schools, school boards, universities, colleges, provincial and federal authorities responsible for training, and the community, should be nurtured to ensure that facilities have a high usage level. Collaboration would also reduce installation and operational costs.

- Efforts should be made to ensure that rural and remote areas of the country are served adequately and at reasonable cost by communication networks.

PROPOSED STEPS

It is important to identify some new directions for the future that would lead to the deployment of C&IT in schools and the eventual connection of educational institutions to the Information Highway. There are several steps Canada can take to facilitate the introduction of new technologies in the classroom.

1. The provincial and federal ministers responsible for education and the Information Highway should collaboratively undertake the development of a strategy to deploy technology in education.

2. Educators should be provided with seed funding for small initiatives to stimulate the use of technology in the classroom using a model similar to that of the Education Technology Centre of British Columbia with their Technology Development Project Grants (TDPs).

3. Seed funding should be provided to form an association of organizations interested in technology in education, which will maintain a national resource centre on the subject. The centre would make available documents from all the Ministries of Education and other sources related to technology in education. The association could organize local and national conferences and

provide training for educators. While such associations are active at the provincial level, a Canada-wide association would add value for educators, increasing communications with those sharing similar interests and providing a critical mass to address complex issues.

4. A cross-Canada network of research centres in the field of technology-based learning should be formed. These centres should disseminate the results of their activities and thereby increase their profile. Funding could be provided to support research in the use of technology, to determine the impact of new technologies on learning, to determine the best practices and to facilitate the deployment of those most promising. The alliance would work closely with the faculties of education to transfer the knowledge of its members to new teachers being trained and to the professors teaching them.

5. Following the example of many provinces, the federal government should provide public education and learning institutions with access to the government inter-city services at periods of low usage. More than one million hours on the digital network could be made available for teaching, at minimal cost to the federal government. This would give institutions the opportunity to radiate their expertise across the country.

6. Funds should be provided to conduct several (10 to 20) case studies on the cost and benefits of supporting technology-assisted education compared to the traditional system. The case studies, based on a common methodology, would be representative of different needs from across the country. The case studies would not replace pilot projects used to test new pedagogical concepts.

7. Statistics Canada should gather and disseminate comprehensive statistics related to technology in education. Such statistics are currently unavailable, either nationally or on a regular basis.

8. The development of French content on the network, and of software to take full advantage of the opportunities offered by technology-assisted learning, should be supported. The current lack of French resources on the network makes the use of networks to access information in French schools very ineffective. Funding for Aboriginal languages content should be also considered. French and Aboriginal languages content could be derived from existing sources (e.g. newspaper, books, radio and TV) to reduce costs.

9. Help should be provided in the formation of co-operatives to purchase C&IT equipment, services and software to benefit from volume pricing and to reduce redundancy.

CONCLUSION

The use of C&IT in education is very effective when it is well carried out, but the implementation and ongoing costs can be high. Over the past decade, many experiments have been carried out and best practices have emerged. If the lessons learned from these projects were used in the widespread application of technology in schools, results could be dramatic. The large sums of money invested could be offset by making Canadians better prepared to find employment. The use of C&IT provides a more enjoyable learning environment that could help reduce the drop-out rate, and increase retention rates and overall academic achievement.

Drop-out, illiteracy and numeracy problems cost several billion dollars each year to the Canadian economy in lost productivity, lost earnings, and unrealized tax revenues, as well as in additional expenditures to address related social problems. If technology in schools could address only part of those problems, the investment would be easily and quickly repaid.

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APPENDIXES

APPENDIX I

EDUCATION STATISTICS

SCHOOLS AND INSTITUTIONS IN CANADA

Estimations for 1993-94

PROVINCE	Elementary-secondary	Community colleges	Universities
Newfoundland	497	12	1
P.E.I.	68	2	1
Nova Scotia	519	10	12
New Brunswick	444	8	5
Quebec	3 335	89	8
Ontario	5 574	32	22
Manitoba	838	10	6
Saskatchewan	960	1	3
Alberta	1 830	18	5
B.C.	2 050	19	6
Yukon	32	1	-
N.W.T.	80	1	-
Overseas (DND)	4	-	-
CANADA	**16 231**	**203**	**69**

FULL-TIME ENROLMENT, BY TYPE OF INSTITUTION

Estimations for 1993-94

PROVINCE	Elementary-secondary	Community colleges	Universities*
Newfoundland	120 560	4 460	13 720
P.E.I.	24 410	1 400	2 830
Nova Scotia	169 820	2 830	30 260
New Brunswick	139 830	3 800	20 310
Quebec	1 148 950	174 510	141 350
Ontario	2 109 290	111 170	234 470
Manitoba	221 680	4 570	20 860
Saskatchewan	208 040	3 820	23 340
Alberta	547 860	27 030	51 650
B.C.	646 780	30 620	46 410
Yukon	5 970	290	-
N.W.T.	17 210	565	-
Overseas (DND)	500	-	-
CANADA	**5 360 900**	**365 065**	**585 200**

* Regular winter session only

FULL-TIME TEACHERS, BY TYPE OF INSTITUTION

Estimations for 1993-94

PROVINCE	Elementary-Secondary	Community colleges	Universities
Newfoundland	7 546	370	1 050
P.E.I.	1 355	110	180
Nova Scotia	10 180	300	2 100
New Brunswick	8 270	430	1 300
Quebec	63 150	12 560	9 150
Ontario	122 590	8 010	14 250
Manitoba	13 150	430	1 800
Saskatchewan	11 030	430	1 500
Alberta	28 610	2 300	3 250
B.C.	33 300	2 180	3 300
Yukon	406	40	-
N.W.T.	1 150	100	-
Overseas (DND)	60	-	-
CANADA	**300 797**	**27 260**	**37 880**

EXPENDITURES ON EDUCATION, BY LEVEL

LEVEL	1990-91	1993-94 (estimations)
Elementary-Secondary:		
Public	$29.3 B	$33.4 B
Private	1.4 B	1.6 B
Subtotal	30.7 B	35.0 B
Post-secondary:		
Community college	3.6 B	4.1 B
University	10.4 B	11.2 B
Subtotal	14.0 B	15.3 B
Vocational Training	4.0 B	5.2 B
TOTAL	**$48.7 B**	**55.5 B**

Expenditures on education:

As a percent of personal income - 8.1% (1989) and 8.9% (1992)
As a percent of GDP - 6.9% (1989) and 8.1% (1992).

Per capita: $1 697 (1989) and $2 017 (1992).

Per capita of labour force: $3 297 (1989) and $4 006 (1992).

As a percent of total provincial and local government budgets:
23.2% (1989) and 23.9% (1991).

EXPENDITURES ON EDUCATION BY DIRECT SOURCES OF FUNDS

	1990-91	1993-94 (estimations)
Local governments	$ 9.8 B	$ 11.3 B
Provincial & Territorial governments	29.3 B	32.4 B
Federal government	4.9 B	6.3 B
Non-government (private)	4.7 B	5.4 B
TOTAL	**$ 48.7 B**	**$ 55.5 B**

TOTAL ELEMENTARY AND SECONDARY ENROLMENT, BY GRADE, CANADA, 1993-94

Pre-elementary	460 570
Grade 1	401 491
Grade 2	394 186
Grade 3	397 253
Grade 4	394 505
Grade 5	392 577
Grade 6	389 032
Grade 7	409 249
Grade 8	393 617
Grade 9	409 782
Grade 10	404 868
Grade 11	396 998
Grade 12	440 502
Elementary ungraded	42 335
Secondary ungraded	33 915
TOTAL	**5 360 880**

NUMBER OF ELEMENTARY AND SECONDARY SCHOOLS, 1993-94

Public	14 361
Private	1 496
Federal	374
TOTAL	**16 231**

NUMBER OF FULL-TIME TEACHERS, 1993-94

Public	282 100
Private	15 582
Federal	3 115
TOTAL	**300 797**

TOTAL ENROLMENT - ELEMENTARY AND SECONDARY SCHOOLS, 1993-94

Public	5 042 200
Private	262 210
Federal	56 530
TOTAL	**5 360 940**

FULL TIME TEACHER / STUDENT RATIO

Public	1 to 18
Private	1 to 17
Federal	1 to 18
TOTAL	**1 to 18**

The source for all statistics in Appendix I is Statistics Canada, Advance Statistics of Education, 1993-94, Catalogue 81-220, September 1993.

APPENDIX II: FAMILY STRUCTURE

FAMILIES BY FAMILY STRUCTURE AND SELECTED CHARACTERISTICS, 1991

	MARRIED-COUPLE FAMILIES	COMMON-LAW FAMILIES	MALE LONE-PARENT FAMILIES	FEMALE LONE-PARENT FAMILIES
Total number of families	5 675 510	725 950	168 240	786 470
Without children at home	2 155 900	423 950		
With children at home	3 519 610	302 005	168 240	786 470
all aged 18 yrs and over	792 435	24 990	70 710	275 610
some aged 18 and over & some aged 17 and under	412 515	15 580	13 975	57 630
all aged 17 and under	2 314 655	261 440	83 555	453 555
all aged under 6 years	698 005	118 530	14 805	124 320
Total number of children at home 24 and under	6 395 550	488 795	210 160	1 033 735
Families by number of never-married children at home				
one	1 222 185	162 805	104 705	455 170
two	1 540 815	99 250	47 000	239 740
three	578 510	29 625	12 685	69 875
four	138 280	7 785	2 870	16 305
five or more	39 820	2 525	985	5 385
Average number of children per family	1.20	0.70	1.5	1.6
Total families	7 356 170			

Source: Statistics Canada, "Families: Number, Type and Structure," Catalogue 93-312, July 1992.

APPENDIX III: FAMILY INCOME

1992 HOUSEHOLD INCOME, CANADA

TYPE OF HOUSEHOLD	AVERAGE	MEDIAN
Total	$46 765	$40 110
One-Person Households	$23 945	$18 158
Single-Family Households	$53 762	$48 010
- no single kids under 18	$53 039	$45 694
*married couples only	$48 983	$41 084
*others	$59 640	$53 641
- with single kids under 18	$54 504	$50 253
*married	$59 564	$54 631
*single parents	$25 738	$20 651
Multi-Family Households	$57 388	$50 266

HOUSEHOLD INCOME consists of incomes received by all individuals 15 years of age & over who at the time of the survey formed one household.

ONE-PERSON HOUSEHOLD: dwelling is occupied by one resident.

SINGLE-FAMILY HOUSEHOLD: entire household comprised of single economic household which is a group of individuals related by blood, marriage (including common-law relationships) or adoption; there are no unrelated individuals living in that dwelling.

MULTI-FAMILY HOUSEHOLD: any household formed by two or more unrelated persons (unattached individuals), by two or more economic families or a combination of families and unattached individuals.

Source: Statistics Canada, "Household Facilities by Income and Other Characteristics," Catalogue 13-218, February 1994.

APPENDIX IV: PERSONAL COMPUTER PENETRATION

HOME COMPUTER PENETRATION, 1993 — 23%

PC PENETRATION BY INCOME

QUINTILE, 1992 ESTIMATES

	UPPER INCOME LIMIT	PENETRATION
Lowest quintile	$18 318	7 %
Next quintile	$31 707	11 %
Middle quintile	$47 000	17 %
Fourth quintile	$67 633	26 %
Top quintile	.....	40 %

PC PENETRATION BY 1992 HOUSEHOLD INCOME

($ thousands)

Under 10	10.80 %
10-14	8.40 %
15-19	9.80 %
20-24	12.60 %
25-29	17 %
30-34	15.20 %
35-44	19.20 %
45-54	23.90 %
55-70	31.60 %
Over 70	45 %

Single family with children under 18 - PC Penetration = 33.6 %

Median income of households with a computer = $59 326
Average income of households with a computer = $65 192

Source: Statistics Canada, Household facilities by income and other characteristics, 1993, Catalogue 13-218, February 1994.