The Impact of Computer Use on Reading Achievement of 15-year-olds

Final report

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Section I
Introduction

Skills related to information technology are more and more important in our society. We now use computers in almost all types of jobs. Furthermore, access to personal computers in non-work locations has also increased substantially over the last two decades. It is not exceptional for our children now to have access to computers before going to school. Teenagers often are more familiar with computers and the Internet than their parents. When in school, some youth are even more familiar with computers than their teachers. Does access to computers have a positive impact on improving skills required for successful future?

Reading skills lie at the basis of all learning that in turn produces a knowledgeable society as well as a highly skilled labour force. The purpose of this study is to investigate the impact of Information and Communication Technologies (ICT) on the reading performance of 15 year-old Canadians.

The OECD's Programme for International Student Assessment (PISA) provided necessary data to investigate the reading skill levels of 15 year-old youth. PISA 2000 along with a wide range of ICT related variables also looked at two aspects of computer familiarity: interest in computers, and a self-assessment of student's attitudes and ability to work with computers. This information allowed for an investigation into the effects of ICT on students' reading skills.

The following five research questions were explored:

- Does access to a computer and the Internet influence students' reading achievement/ performance?
- Is the frequency of ICT usage associated with students' reading performance?
- Are different types of computer usage associated with students' reading scores?
- Does the information and communication technology influence certain aspects of the reading skills as measured by PISA (i.e. retrieving information, interpreting text and reflecting on text)?
- When individual and family variables are controlled for, how does computer usage and computer familiarity influence reading achievements?

Section two of the report presents an overview of recent literature on the effects of computers on educational outcomes. Section three provides a discussion of PISA data. Section four presents a profile of computer access and use, including frequency and type of usage, as well as attitudes towards computers as held by 15-year-old Canadian students. Section five examines the relationship between reading and computer use, where numerous ICT variables were analysed separately with respect to PISA reading scores. Section six deals with results of a regression analysis, where multivariate models were analysed using an OLS methodology. Finally, the study is concluded in section seven and subsequent policy implications are presented.

Section II
Literature review

There is an increased urgency to understand the impact of computers on achievement. Numerous recent studies have examined this link and found mixed effects. This section presents an overview of published literature that looks at the effect of ICT related variables on achievement. First, literature that found positive links is presented, followed by studies that found either no impact or negative effects on students' outcomes.

Attewell et al. (1999) using the National Longitudinal Study of 1988 data found that having a computer at home is associated with higher test scores in mathematics and reading. The results were consistent even after controlling for family income and cultural and social capital. Cultural capital was defined as belonging to differently educated families. It was speculated that children (8^{th} graders) with higher cultural capital were more likely to perform better on educational tests. Social capital was defined as the level of supportive activities from either the community or family. In this case it was also expected that kids with higher levels of social capital should perform better on school tests.

Attewell et al. (1999) also reported that children with higher levels of either social or cultural capital who possessed a computer at home scored higher than those in lower levels of the two even if they possessed a computer. They concluded that home computing may generate another "Sesame Street Effect" whereby an innovation that held great promise for poorer children to catch up educationally with more affluent children is, in practice, increasing the educational gap between affluent and poor, between boys and girls, and between ethnic minorities and whites.

British Educational Communications and Technology agency BECTa (2000) performed a study looking into the correlation between educational performance and access and usage of Information and Communication Technology (ICT) in British schools. The study used: English, mathematics, and science test scores. 2,500 primary schools in England participated in the study. For the analysis, schools were divided into ICT resource categories. In English, BECTa (2000) used the 1999 grades from national tests. They found that primary schools with 'Very Good' ICT resources were significantly more likely to gain good grades on the national tests.

Mann et al. (1999) looked at the impact of technology on school performance in West Virginia. The researchers examined the educational outcomes of the West Virginia Basic Skills/Computer Education (BS/CE) program, which began in 1990-1991. Mann et al. (1999) reported that West Virginia had provided $7 million to equip every elementary school with computer equipment. The study showed that students who were exposed to the BS/CE program scored higher on the Stanford-9 state exam. The researchers calculated that the scores rose 11 percent and it was attributed to BS/CE. The study also revealed that although all students participating in the program benefited, it was the neediest students who benefited the most. According to Mann et al. (1999) "Those children without a computer at home made the biggest gains in total basic skills, total language, language expression, total reading,

reading comprehension and vocabulary." These findings were contrary to those of Attewell et al. (1999) who discovered a widening gap between children from rich and poor families.

A report titled, Idaho Technology Initiative: An Accountability Report to the Idaho Legislature, by the state Idaho Council for Technology in Learning (1999) sampled 35,885 students from grades eight and eleven. Based on the findings from the sample group, the researchers concluded that there exists enough evidence to say that technology has significant benefits on educational performance. According to this study, the benefits included an increase in academic achievement in reading, mathematics, language, and core studies which in turn improved technology literacy, communication, innovative teaching, positive relationship with community, more efficient operation of schools and technically qualified students ready to enter today's workforce. Out of all reviewed studies supporting the range and magnitude of benefits of ITC, this report was the most positive in terms of these benefits. However, this report might have been influenced by its purpose which was to justify the expenditure of one-time and ongoing funds to purchase and integrate technology into the state's K-12 public schools.

Rockman et al. (2000) investigated the impact of laptop computers on students' and teachers' attitude and performance in schools. Students in certain American schools were provided with their own personal laptop computers. The researchers found that the use and access to laptops had a broad positive effect on both students and teachers. 'Laptop students' compared to their 'non-laptop peers' outperformed them in all four scored areas of a writing assessment (content, organization, language and mechanics). Teachers in those schools also reported an improvement in writing. According to Rockman et al. (2000), laptops encouraged collaboration among students. 'Laptop students' assumed a greater variety of roles in the classroom with activities such as students teaching students and students teaching teachers.

The Rockman et al. (2000) study also found a change in the teaching practices of the educators. 'Laptop teachers' were more likely to use teaching practices that put students at center of learning (discussion rather than lectures). The teachers themselves reported greater ability to control and manage student learning. However, the study found no improvement in the performance on standardized test scores.

Renaud (1998) analyzed the impact of in-school computer use on science performance of seventh grade low-achievers. The study found a positive relationship between computer use and achievement as a function of exposure to computer assisted science instructions. Similarly, van Daal et al. (2000) reported dramatic increases in reading and spelling performance of kindergarten students (K2) who were exposed to a computer based reading and spelling program compared to those not exposed to computerized programs.

Studies suggesting that exposure to and the use of computers might have no impact or even negative effects on children's educational performance are also emerging and quite common.

Harold Wenglinsky's (1998) examination of 14,000 U.S. fourth and eighth grade students from 1996 showed that using computers for rote learning and math drills seemed to harm students' test performance. His study found that among eighth-graders who used computers in the classroom mainly for math drills such as dividing fractions, test scores averaged half a grade lower than those of other students. According to Wenglinsky (1998), this is due to the fact that such exercises do not encourage the kind of higher-level thinking necessary to grasp certain mathematical concepts.

However, Wenglinsky (1998) highlighted the difference that quality of usage can make. In his study he found that eighth-graders who had access to computer programs that encouraged what his study called "higher-level cognitive practices" scored two-fifths of a grade level higher than those who did not use computers for such purposes. The study found that those students in grade 8 were impacted more by technology than students in grade 4. Wenglinsky (1998) also reported the importance of teacher's computer skills, as he concluded that the proper thinking fostered by the computer application along with the teachers' skill in using that technology will provide increased scores in student testing.

The importance of social capital as highlighted by Attewell et al. (1999) was also reported by Giacquinta et al. (1993). According to the authors, the rare instances where computers were used for educational purposes were almost always initiated by the parents. When social capital was absent, kids would avoid such practices and focus entirely on playing games.

Angrist et al. (2001) investigated the effect of computers on test performance of both 4th and 8th graders in Israeli schools. The authors reported that according to an Israeli teachers' survey, the influx of new computers into schools increased teachers' use of computer-aided instruction (CAI) in the 4th grade, with a smaller effect on CAI in the 8th grade. When it came to students' test scores, Angrist et al. (2001) found no evidence of a relationship between CAI and test scores, except for a negative effect on 8th grade math scores. When it came to the 4th graders, the estimates showed lower math scores for those with computers.

Kleiman (2000) focused on technology and its impact on education. In his paper, he recognized problems faced by the education system upon arrival of the new wave of technology. According to the author, the United States Federal government spent $6.9 billion on new technology for schools in 1999. This was a large investment and as Kleiman (2000) concluded it is going to be a long time before such an investment starts paying off. The author recognized issues that make it a long run investment. According to him, the most important one is that the educational system is not ready to enter a new curriculum style. Teachers are not ready to use the technology. It is hard for teachers to introduce technology into the existing teaching curriculums. They often do not possess the necessary skills to use the new technology. The technical support is often limited, and teachers often find themselves lacking the software that supports major curriculum goals. The major conclusion being that access alone is not a mean to improved educational performance, supporting Wenglinsky (1998) and his conclusion "it is not how often you use it, it is how you use it."

The National Assessment of Educational Progress (NAEP) test is administered nationally every two years covering mathematics and reading alternately, and assesses the effects of a number of variables, including computer use on academic achievement. Using the NAEP, Johnson (2000) revealed that students who use computers in the classroom at least once a week do not perform better on the NAEP reading test than do those who use computers less than once a week. Johnson's results were confirmed in 2001 through a study by Tremblay et al. (2001) which found no relationship between the presence of a computer in the classroom and the achievement of third grade students. This study was based on the data from Ontario's Education Quality and Accountability Office's province-wide test.

The reviewed literature painted a mixed picture in terms of the impact that ICT might have on students' academic performance. A number of studies exploring this phenomenon were conducted ranging in methodology from descriptive to multivariate. An overall lack of Canadian studies was apparent in the literature. In addition, a shortage of studies on the use of the Internet and its effect on outcomes was discovered.

Cost-benefit analyses revealed the tremendous costs associated with the introduction of ICT in teaching and learning, which were often higher than the more traditional and proven methods. However, over the last several years the costs of ICT have decreased dramatically raising questions about the validity of earlier research.

ICT is and will continue to be a growing force in students' lives. Therefore, as stressed in some of the reviewed studies the emphasis should be put on the type and quality of ICT use in order to produce positive results. Simple access and an unrealistic attitude that computers will solve all problems might be very costly and even counterproductive as concluded by some researchers.

Section III
Data and definitions

The objective of this section is to present some basic information about the surveys used for this research, including some important results as well as key definitions and concepts used in the remaining chapters.

3.1 About PISA and YITS

In spring 2000, more than 250,000 students aged 15 from 32 countries participated in the Programme for International Student Assessment (PISA) initiated by the Organisation for Economic Co-operation and Development (OECD). PISA is a collaborative effort among OECD member countries to assess youth skills and knowledge in three domains: reading, mathematics and sciences. The domains are defined in Box 3.1.

Box 3.1

PISA domains

The following are definitions, as agreed by international experts from OECD member countries, of each of the three PISA domains evaluated in 2000 (OECD, 1999).

Reading literacy: "Understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society."

Mathematical literacy: "The capacity to identify, to understand, and to engage in mathematics and make well-founded judgements about the role that mathematics plays, as needed for individuals' current and future private life, occupational life, social life with peers and relatives and as a constructive, concerned and reflective citizen."

Scientific literacy: "The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity."

Source: OECD, 2001b

In Canada, over 30,000 15-year-old youth participated in PISA 2000. They came from more than 1,000 schools randomly selected from 10 provinces. The large sample size in Canada allows reporting of results at national as well as provincial levels, and for both English and French language school systems in Nova Scotia, New Brunswick, Quebec, Ontario, and Manitoba.

Additionally, to measure levels of performance, reading scores were summarized into five proficiency levels, level 5 being the highest level of proficiency and level 1 being the lowest. Some students performed below level 1, which meant that they were not able to demonstrate the most basic skills that PISA sought to measure. The proficiency levels are profiled in Box 3.2.

Box 3.2

PISA proficiency levels were defined as follows:

- *Proficiency at level 5* (above 625 points)
  Capable of evaluating information and building hypothesis, drawing on specialized knowledge, accommodating concepts contrary to expectations.
- *Proficiency at level 4* (from 553 to 625 points)
  Capable of difficult reading tasks, such as locating embedded information, constructing meaning from nuances of language and critically evaluating a text.
- *Proficiency at level 3* (from 481 to 552 points)
  Capable or reading tasks of moderate complexity, such as locating multiple pieces of information and relating it to familiar everyday knowledge.
- *Proficiency at level 2* (from 408 to 480)
  Capable of basic reading tasks, such as locating straightforward information and using some outside knowledge to understand it.
- *Proficiency at level 1* (from 335 to 407)
  Capable of recognizing main themes on a familiar topic as well as making simple connections.
- *Proficiency below level 1* (less than 335 points)
  Capable of reading, but have not acquired necessary skills to use reading for learning.

Source: OECD, 2001b

The Youth in Transition Survey (YITS) was administered simultaneously with PISA to Canadian students. YITS is a longitudinal survey designed to examine key transitions in young people's lives, particularly with respect to education, training and work. Current plans for YITS are to survey youth every two years, over a period of several years.

The integration of PISA and YITS enables examination of the relationship between education and labour market outcomes of youth, and trajectories, beginning with their tested skills and knowledge at age 15.[1]

3.2 First results

The PISA results showed that Canadian students performed well compared with their international counterparts ranking second in reading, fifth in science and sixth in mathematics. Moreover, only two countries performed significantly better than Canada in mathematics and three did so in science.

Provincial results were also positive at an international level with all provinces scoring at or above the OECD average in all three domains. However, some noticeable differences were found at the national level. The performance of Alberta students was significantly above the Canadian average in all three domains, as was the performance of Quebec students in mathematics and science.[2] Students from the Atlantic Provinces performed at a lower level, while the performance of students from Ontario, Manitoba, Saskatchewan, and British Columbia was similar to the Canadian average.[3]

3.3 Key concepts and data

Results for reading achievement, the major domain of PISA 2000, were evaluated for three different types of reading tasks; retrieving information, interpreting information, and reflecting and evaluating. Definitions on the three types of reading skills can be found in Box 3.3.

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[1] Readers interested in knowing more about YITS should refer to *Youth in Transition Survey: Project Overview* (HRDC and Statistics Canada, 2000) while the PISA framework is presented in *Measuring Student Knowledge and Skills: A New Framework for Assessment (OECD, 1999*).

[2] Since the major focus of this report is on the impact of computer use on reading achievement, no further references will be made to the two minor domains of PISA 2000 (mathematics and science).

[3] More detailed results from PISA can be found in *Measuring Up: The performance of Canada's youth in reading, mathematics and science* (Bussière et al., 2001) and in *Knowledge and Skills for Life: First Results from PISA 2000* (OECD, 2001b).

Box 3.3

Results of reading, the major domain in PISA 2000, were evaluated for three different types of reading tasks, defined as follows:

- *Retrieving information*: Ability to locate information in test
- *Interpreting information*: Ability to construct meaning and draw inferences from written information
- *Reflecting and evaluation*: Ability to relate text to their other knowledge, ideas and experiences

Source: OECD, 2001

It is also important to note that PISA and YITS used a complex sampling design (stratified, two-stages, PPS sampling). A balanced repeated replication methodology (BRR) was employed to estimate the sampling variances of PISA and YITS estimates. This results in a set of 80 BRR weights which are available in the data file and were used throughout the analysis.

Finally, the data set contains plausible values. Plausible values are not test scores, they are random values that are drawn from the distribution of scores that could be reasonably assigned to each individual. Plausible values are better suited to describing the performance of the population than a set of scores that are optimal at the individual level. In PISA, each performance outcome is measured by a set of five plausible values. The following analysis used the PISA plausible values. For more information on PISA sampling methodology refer to the PISA 2000 Technical Report (OECD, 2002a and OECD, 2002b).

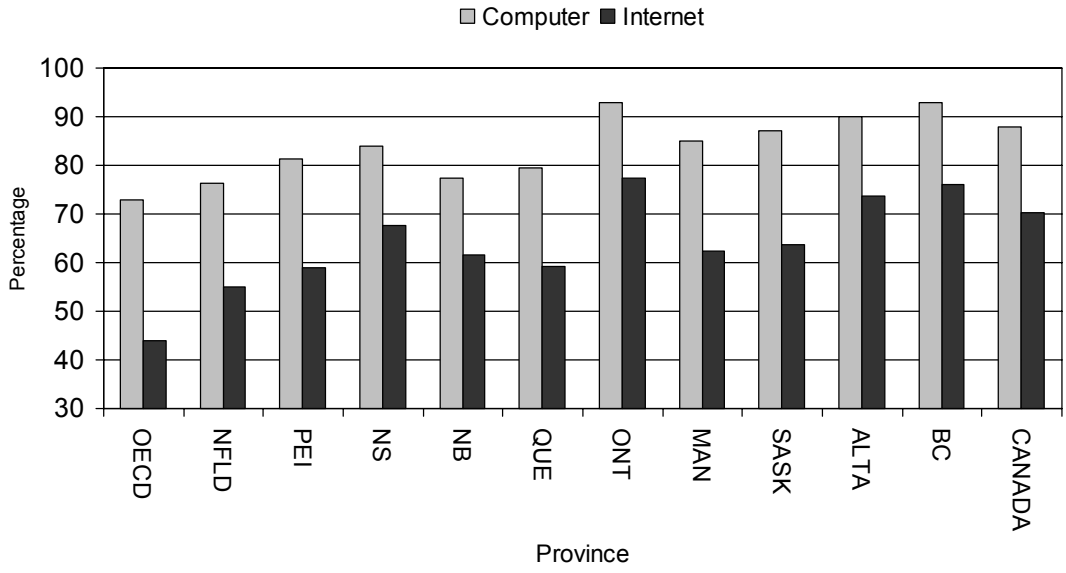
Section IV
ICT – access, types of use, and attitudes

This section presents descriptive results from the PISA and YITS studies. A variety of results with respect to a range of ICT variables are presented. These included access to ICT, the frequency and types of ICT use, also broken down by province and gender.

4.1 Access to computers and Internet

According to PISA participants, 87.9% of 15-year-old Canadian students have at least one computer available to them at home. This puts Canada well above the OECD average of 73% (Figure 4.1.1).

Figure 4.1.1
Percentage of 15-year-olds reporting home computer and Internet access, by province



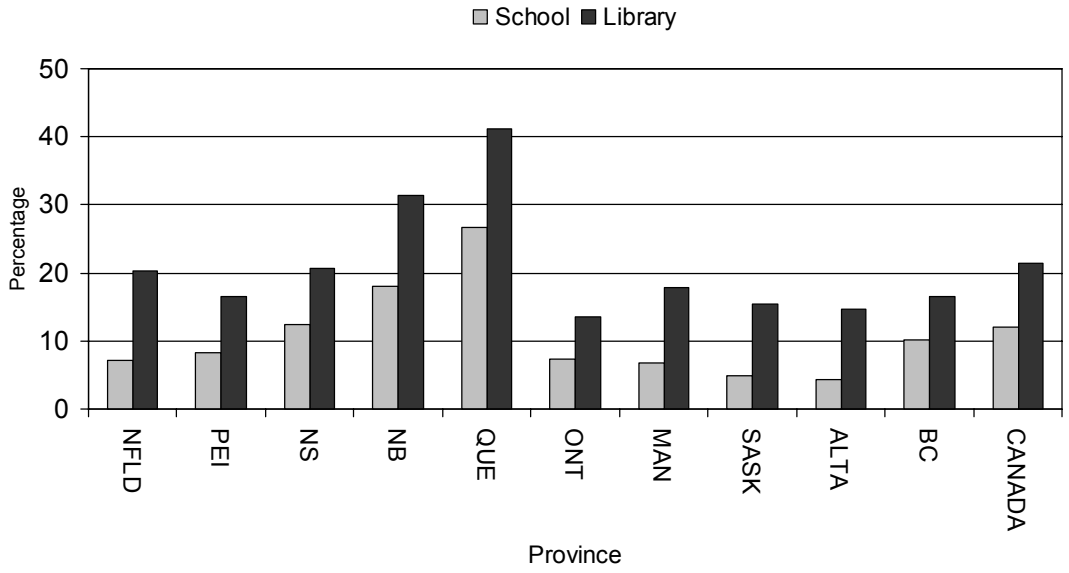
Source: Programme for International Student Assessment 2000.

There were large provincial differences in the incidence of possessing a computer at home. Students from both Ontario and British Columbia reported the highest incidence of access to a computer at home (93% for both provinces). Students from Newfoundland and Labrador were the lowest at 76.2%. It is worth highlighting that all Canadian provinces were well above the OECD average of 73%. This study did not find any gender differences in terms of home computer access. Girls were as likely to come from homes with computers as were the boys.

Additional findings showed that, 70.2% of 15-year-olds in Canada had Internet access from home (Figure 4.1). The incidence of home Internet access varied across the provinces. Both Ontario and British Columbia reported the highest rates of Internet access in Canada (77.3% and 76.1% respectively). Newfoundland and Labrador, Prince Edward Island and Quebec reported the lowest rates of home-Internet access. On the international stage, Canada came well above the OECD average (44%) in this measure. In terms of gender differences, boys held a small advantage over girls.

Just over one in ten respondents (12.1%) reported almost never having access to computers at school. This figure was higher for no access to computers in libraries, and stood at 21.5% (Figure 4.1.2).

Figure 4.1.2
Percentage of 15-year-olds reporting frequency of computer access at school and library of less than once a month, by province



Source: Programme for International Student Assessment 2000.

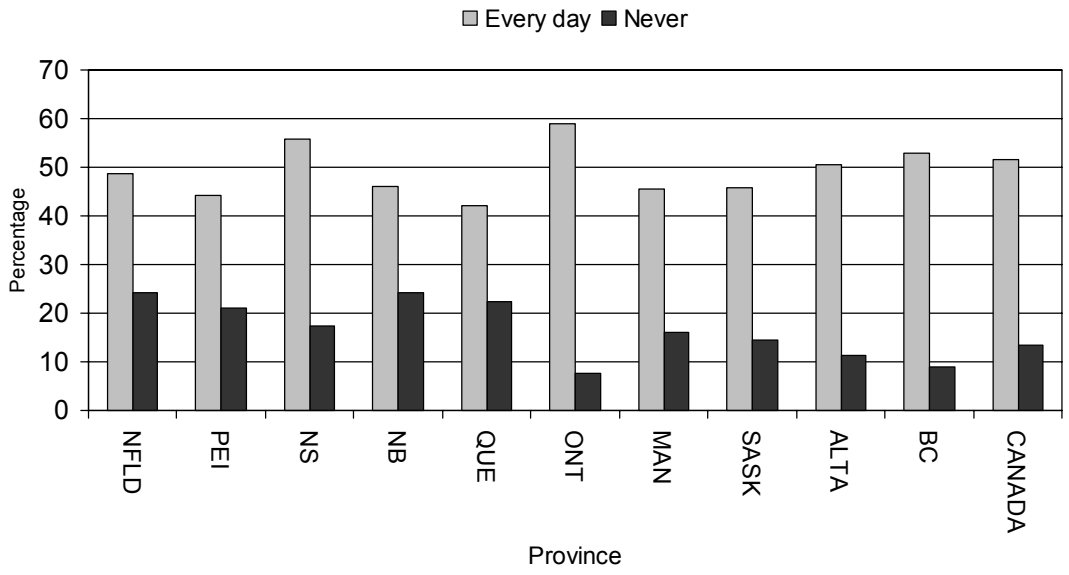
More respondents from Quebec and New Brunswick than other provinces reported almost no computer access at school or in libraries. In the case of no school computer access, these two provinces as well as Nova Scotia were above the Canadian average.

4.2 Frequency of ICT usage

PISA included questions that measured the frequency of computer usage by the location of access. Given that a majority of Canadian students had a computer at home, the home was the place where they used computers most often. On average, just over half Canadian 15-year-olds (51.6%) reported using computers at home every day (Figure 4.2.1). There were some provincial differences in this category, with Quebec reporting the lowest rates and Ontario highest. There were substantial gender

differences: PISA data showed that 57.9% of boys used computers every day at home compared to 45.3% of girls.

Figure 4.2.1
Reported frequency of computer usage at home by 15-year-olds, by province



Source: Programme for International Student Assessment 2000.

The use of computers is not limited to one's home. Other places offering access to computers include schools and libraries. Nearly one-fifth (18.1%) of Canadian respondents used school computers every day. When combined with those that used it few times a week, this figure more than doubled to 39.3%. This figure was almost matched by the response rates of those using school computers less then once a month or never (37.8%). The rates of those using school computers at least few times a week was highest in Manitoba and lowest in Quebec (53.1% vs. 26.5%). There was a large gender difference in terms of using computers at school: 44.7% of boys reported using computers at school almost every day compared to only 34% of girls.[4]

Using computers in libraries was not a favourable option for Canadian students. Across Canada, only 13.5% of the respondents reported using computers in libraries at least a few times per week. This compared to 65.4% reporting using them less than once a month or never. In terms of frequent use, again the provinces of Manitoba and Quebec occupied first and last place (18.5% and 7% respectively). Just as in the case of using computers in school, more boys used them in libraries than girls (15.7% vs. 11.2%).

Of all respondents with home-Internet access, almost six out of ten reported that they used the Internet every day, compared to only 3.4% who reported less than once a month or never. There were large gender differences, with almost two thirds of boys compared with little more than half of girls reporting using the Internet every day.

[4] Note: Tables with all figures discussed in this section are presented in Appendix A.

Just over one-third of Canadian youth (35.5%) without home-Internet access used the Internet at least few times a week. Possible access locations include schools, public and school libraries, friends' homes or even cyber cafes.

4.3 Type of usage

Findings showed that more 15-year-old Canadians used non-entertainment software as opposed to entertainment such as computer games. 51.8% of PISA respondents reported using word processing software at least a few times per week. This figure dropped slightly to 47.6% when it came to games. As well, according to the PISA results, the incidence of students using spreadsheets at least a few times per week was 20.7%.

The students from Newfoundland and Labrador reported the highest rates of playing games on a computer at least a few times a week, and Quebec reported the lowest rates. When it came to word processing software, Ontario was the highest and New Brunswick lowest. Finally, spreadsheets were most widely used by 15-year-olds in Manitoba, and least used in Quebec.

There were noticeable gender differences in the computer software usage. More than twice the proportion of boys (64.1% vs. 31.2%) than girls reported using computers for playing games at least a few times per week. A frequent use of spreadsheets was reported by 18.7% girls and 22.6% boys. This is consistent with other studies that found that more boys than girls engage in computer programming that is required when working with spreadsheets (see Looker and Thiessen, 2002). There were no gender differences found in the usage of word processing software, with over half of boys and girls reporting using it at least a few times a week.

4.4 Attitudes towards ICT

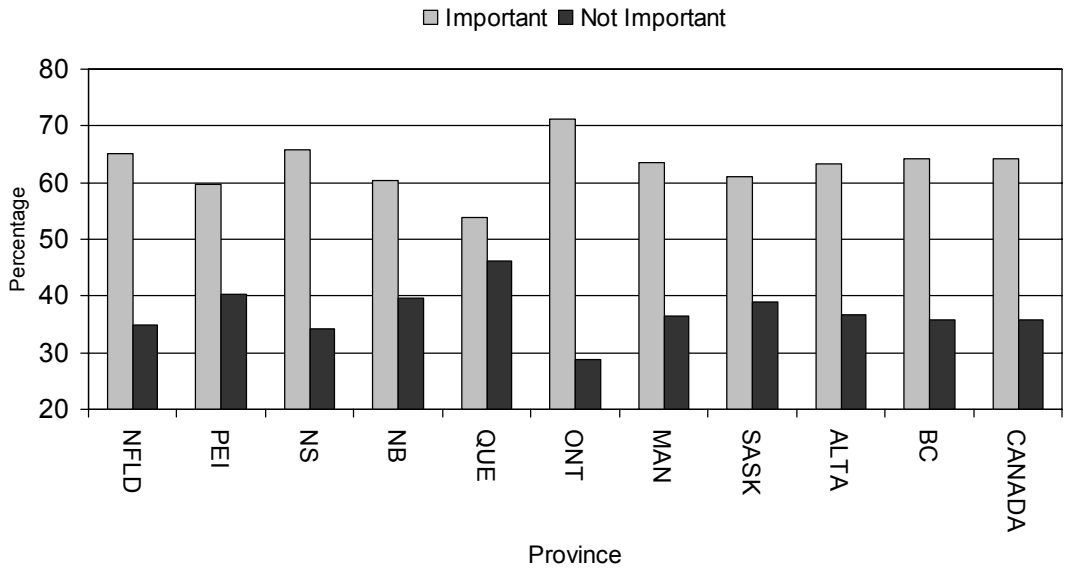
Students were asked in the PISA survey to rank their levels of comfort when using a computer. A large majority (88.6%) of 15-year-olds reported to be comfortable using a computer. This was followed by 9.3% of respondents reporting to be somewhat comfortable. A very small proportion (2.1%) reported to be not at all comfortable. These results suggest that young Canadians were utilizing the technology available to them. Canadian students were more comfortable with computers compared to the rest of the OECD countries. For example, less than three-quarters (71%) of youth in other OECD countries reported to be comfortable with using computers.

There were gender differences in the reported comfort levels of computer usage. 85.4% of girls reported to be comfortable compared to 91.8% boys. Similar results were obtained through other studies (Whitley, 1997; Inkpen, 1997).

Very small provincial differences were observed in the PISA data with respect to the comfort levels of using a computer: ranging from 86% to 90% reporting a moderate to high comfort level. All provinces were above the OECD average of 71%.

Findings showed that 15-year-old Canadians have access to and are utilizing ICT frequently. When asked if working with computers is very important to them, 64.2% of respondents answered 'yes', compared to the OECD average of 59.9%. Almost six out of ten girls said that working with a computer is very important to them compared to seven out of ten boys.

Figure 4.4.1
Percentage of 15-year-olds to whom working with computers is either important or not important, by province



Source: Programme for International Student Assessment 2000.

Most of the provinces came very close to the national average. However, students from Ontario lead Canada with 71.2% of its students considering computers as very important. The province with the smallest percentage of respondents agreeing with the importance of computers was Quebec at 53.9%. Quebec was the only Canadian province that reported lower than the OECD average in this category.

The results presented in this section showed that access to computers is not a problem for 15-year-old Canadians. A vast majority of them reported to have a computer at home as well as a link to the Internet. Over half of the youth took advantage of accessibility and used computers on daily basis. More Canadian youth also used computers for non-entertainment purposes than entertainment. Also, a majority of respondents reported being comfortable with their abilities to use computers.

Section V
Direct impact of selected ICT variables on PISA reading scores

The analysis so far has shown that a vast majority of Canadian youth aged 15 had access to a computer and most of them use it quite often. This section explores the direct relationship (variable's effect in the absence of other variables) between reading literacy and selected information and communication technology (ICT) variables. These included the number of computers at home as well as a link to. Also, do students using computer at home or at school on a frequent basis score higher on the PISA test? Further, is there a linear relationship between PISA reading scores and the usage of computer games? These types of issues were explored in more detail in this chapter in order to find if access and usage of ICT are positively associated with youth knowledge and reading skills.

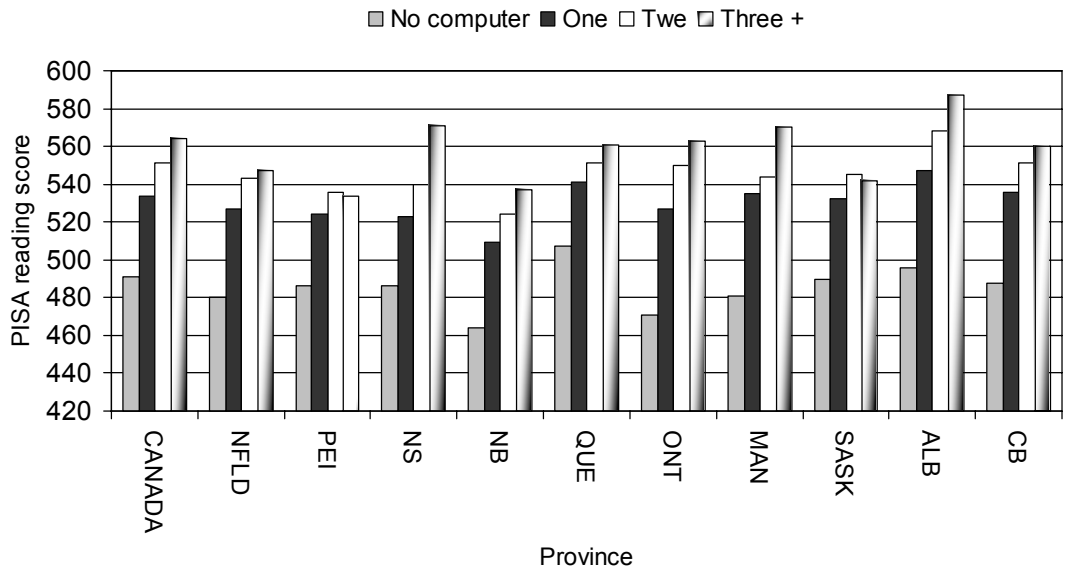
Consistently, similar patterns were found for each of the three dimensions of reading (retrieving, interpreting, reflecting and evaluating). Therefore, the analyses results reported in this section were done only on the overall reading scores.

5.1 PISA reading scores[5] and access to ICT

PISA results showed that there was a positive association between reading scores and home computer access, and this association increased with the number of computers present (Figure 5.1.1). In fact, more than one-half of a reading proficiency level separated those without a computer at home and those with one. Students who reported at least three computers at home outperformed their peers without computers by roughly a full proficiency level (see Box 3.2 for definitions).

[5] Reading scores were attributed on a scale designed to have an average for OECD countries of 500 points and a standard deviation of 100 point. Therefore, two-thirds of the students had scores between 400 and 600 points.

Figure 5.1.1
Relationship between PISA reading scores and number of computers at home

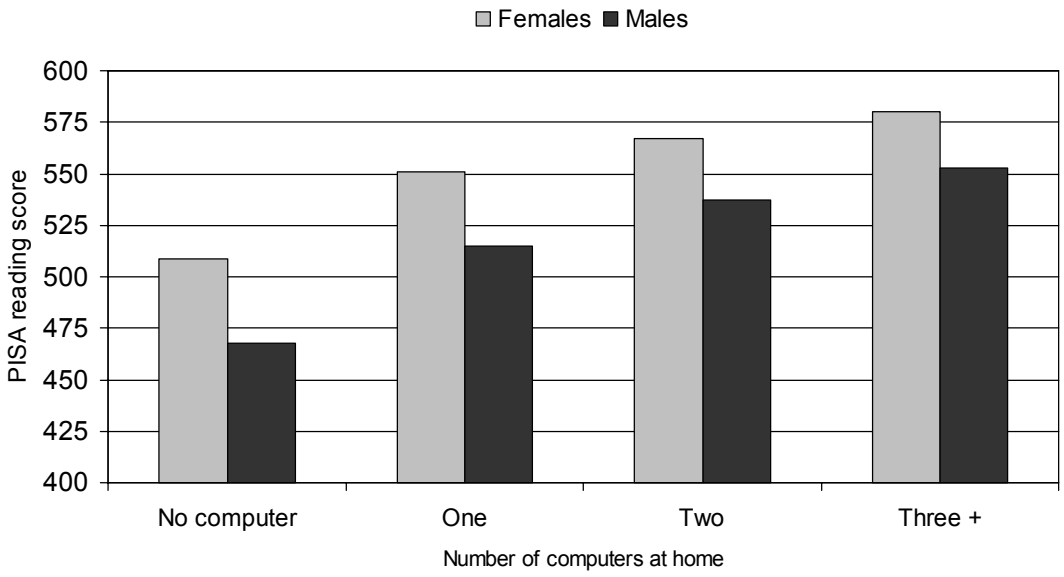


Source: Programme for International Student Assessment 2000.

The smallest difference in reading scores between those with one computer at home and those without one was found in Quebec, while students from Prince-Edward Island had the smallest difference between those without and those with three or more computers at home. Ontario, on the other hand, had the largest difference between students with and without computers at home (irrespective of the number of computers).

The reading scores increased with the number of computers students reported to have at home, for both males and females (Figure 5.1.2). An interesting finding was that the reading score of females who reported having no computer at home was not statistically different from the score of males who reported having one computer at home.

Figure 5.1.2
Relationship between PISA reading scores and number of computers at home, by gender

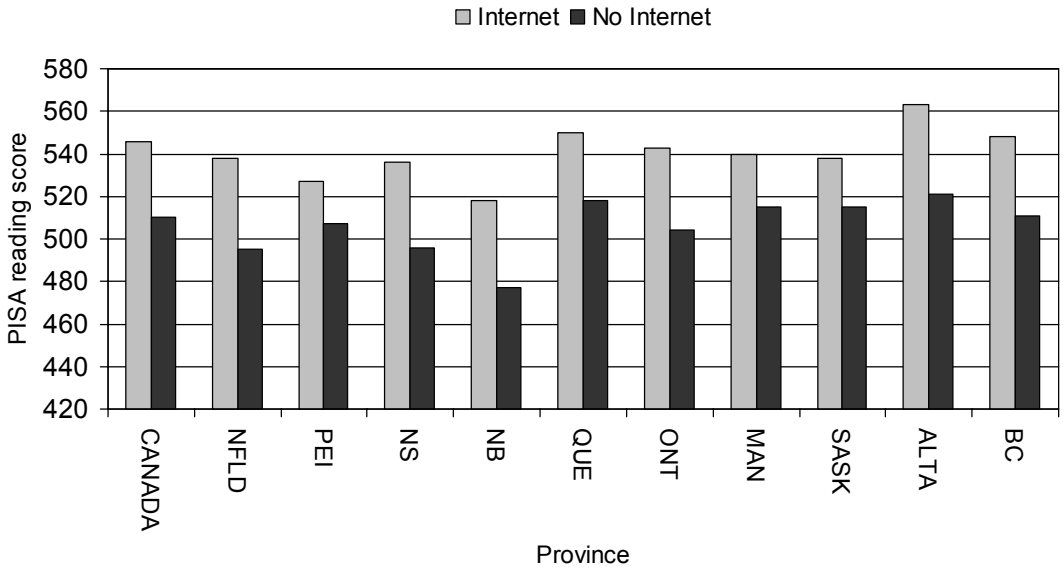


Source: Programme for International Student Assessment 2000.

Next, the relationship between Internet access and achievement was examined. Students who reported to have a link to the Internet at home scored roughly one-half of a reading proficiency level higher than students reporting no home access (Figure 5.1.3).[6] A similar pattern was found in all provinces and for men and women. Again, surprisingly, there was no difference between the scores of men with Internet access and women without Internet access.

[6] Note: Tables with all figures discussed in this chapter are presented in Appendix B.

Figure 5.1.3
Relationship between PISA reading scores and having a link to the Internet at home

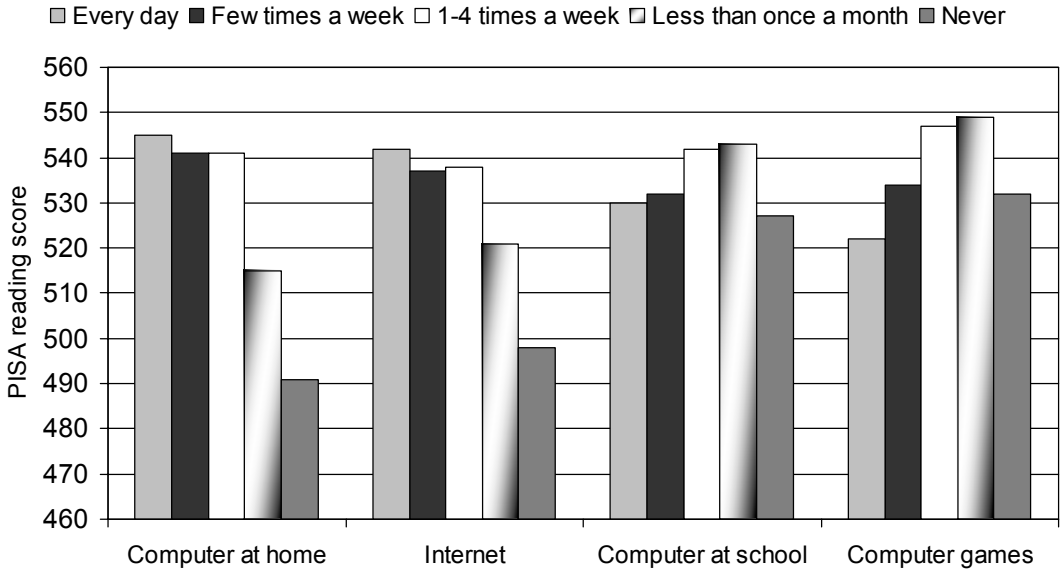


Source: Programme for International Student Assessment 2000.

5.2 PISA reading scores and frequency of ICT use

Next, the relationship between PISA reading scores and the frequency of computer usage at home and at school, as well as the frequency of Internet and computer games usage was examined. As Figure 5.2.1 shows, higher reading scores were associated with frequent use of computers and Internet at home, as well as less frequent use of computers at school and computer games.

Figure 5.2.1
Relationship between PISA reading scores and frequency of usage of: computers at home, Internet, computer at school and computer games



Source: Programme for International Student Assessment 2000.

More specifically, students who reported using a computer at home at least a few times a month had the highest scores on the PISA reading test, while those who reported never using one scored two-thirds of a reading level below their peers. A similar pattern was observed when Internet usage was examined.

It is worth mentioning that, at the provincial levels (Appendix B, Table 5.2.1) Quebec had the smallest difference between students reporting using a computer at home on a daily basis and students reporting never using a computer at home. The difference was approximately half a reading proficiency level. On the other hand, the difference was almost a full reading proficiency level in Ontario, Alberta, and British Columbia. Similarly, the smallest difference between students reporting Internet use on a daily basis and students reporting never using Internet was the smallest in Prince Edward Island, with less than a quarter of a reading proficiency level difference. The largest differences were in Newfoundland and Labrador, and Alberta, with more than one reading proficiency level separating the students from these two groups (Appendix B, Table 5.2.2).

Girls tended to have higher reading scores, so only boys using a computer at home everyday outperformed girls that reported never using a computer. The same pattern is also true for Internet usage.

As stated before, infrequent use of computers at school was associated with higher reading scores. At the Canadian level, students reporting using computers at school few times a year significantly outperformed those reporting never using it or using it at least a few times a week. At the provincial level, the picture was less clear (Appendix B, Table 5.2.3).

For example, in Prince Edward Island, there were no significant differences in reading scores related to the frequency of usage of computers at school. Girls outperformed boys despite the difference in the frequency of computer use at school.

In all provinces as well as nationally, students reporting to never play computer games or playing everyday had lower reading scores than students reporting to play very rarely (Appendix B, Table 5.2.4). In terms of gender, there was no difference in boys reading scores for those playing everyday versus less than once a month. However, girls playing computer games a few times a year clearly outperformed other girls and boys.

The results presented in this section showed a positive relationship between PISA reading scores and many ICT related variables. Access to computers and the Internet tended to be associated with higher scores, as well as moderate frequency of use of these amenities. The relationships studied in this section were obtained without the presence of any control variables. The following section presents results of multivariate analyses which in addition to ICT variables accounted for a series of individual and family characteristics.

Section VI
Multivariate analysis

The previous sections presented results of simple bivariate analyses, where single variables were analyzed in relation to students' PISA reading scores. This section focuses on results of multivariate analyses, where the correlations of multiple variables with reading scores are analyzed.

In order to obtain a representative model, the same mixture of both family and individual variables was included in all regressions as control variables. These variables were chosen based on results from the pan-Canadian PISA report (see Bussière et al., 2001) in which these models were tested. Building on that initial set of individual and family variables, specific groups of ICT variables each dealing with a different theme, were added onto all consecutive models. Five multivariate models were tested. Because of the large size of the models, Table 6.1 presents only regression results for the ICT variables. To see estimates of the entire model refer to Appendix C.

As mentioned before, Model 1 was a basic model of family and individual variables upon which the rest of multivariate analysis was built. These variables included individual information such as gender and enjoyment of reading (for a complete list as well as description of all variables, refer to Appendix C). The family variables consisted of information such as family type, and socio-economic status. In addition, variables representing the ten Canadian provinces were included to account for provincial differences in PISA reading scores.

The following paragraphs describe the differences between the models used to explain the contribution of ICT variables to reading scores while controlling for individual and family variables. Only results of Model 5 which was found to be the most representative model are described in detail in this section.

The first group of ICT variables introduced in Model 2 were those that dealt with the frequency of computer usage at various locations. The four different locations for computer access included in the model were home, school, library, and other places.

Following the PISA assessment, the Organization for Economic Co-operation and Development (OECD) created two indices to measure both interest and the perceived ability to use computers. The index measuring interest was derived from students' responses to questions on the importance of computer use, enjoyment of using computers, as well as reasons for using them. The index measuring the perceived ability was derived from responses to questions on their comfort level of using computers for different tasks as well as their reported skills for working with them. These two indices were introduced into the regression in model 3.

It is widely believed, based on earlier evidence, that boys are more comfortable with computers as well as more interested in them. In Model 4 gender interaction variables were introduced in addition to the two indices of interest and ability.

Socio-economic status could affect computer access and consequently could impact the ability to use them. To test this linkage, interaction variables between socio-economic status and the two ICT indices were included. Neither of the two interaction variables was found to be significant, and therefore these results of the estimation were not presented in this report.

Table 6.1
Results of four multivariate models testing the correlation of ICT variables with PISA reading scores

	Model 2		Model 3		Model 4		Model 5	
VARIABLE	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**
Home computer use	5.36	0.54	4.10	1.68	4.06	0.77	3.82	0.75
School computer use	1.28	0.62	0.74	0.28	[sn]0.76	0.63	1.99	0.67
Library computer use	-5.79	0.85	-5.67	-2.34	-5.64	0.85	-3.95	0.83
Other place computer use	-3.83	0.60	-4.15	-1.68	-4.33	0.59	-2.89	0.59
Index of computer interest			-5.46	0.90	-4.08	1.21	-2.60	1.19
Index of computer ability			10.38	0.91	14.82	1.24	17.76	1.33
Index of computer interest of females					[sn]-2.13	1.53	[sn]-2.04	1.61
Index of computer ability of females					-9.57	1.90	-11.09	1.90
Use of Internet							[sn]-1.47	1.16
Use of e-mail							3.82	0.86
Use of word-processing software							7.32	1.09
Use of computers to learn							[sn]-1.28	0.79
Use of educational software							-5.01	0.87
Computer programming							-7.17	0.68
Computer graphics							-3.35	0.82
Use of spreadsheets							-4.79	0.83
Use of computer games							[sn]-0.85	0.69
R – squared	0.337		0.344		0.348		0.373	

ns - not statistically significant at a 95% level of confidence
For complete table of results see Appendix C.

To Model 4 which included access, frequency, ability, interest and gender issues, a final group of variables on the types of computer use was added to create Model 5. In total, nine different types of usage were represented, ranging from e-mailing to computer programming (For description see Appendix C).

Over and above individual and family characteristics, many computer related variables were found to be statistically significant. Almost 20 points on the reading scale stood between 15-year olds that used computers everyday at home and those that never used them. School computer use was also positively correlated, but not as highly as home usage. Surprisingly, negative correlations were achieved for the other two locations (library and other places). However, as seen in Section IV, the percentage of respondents reporting frequent computer use at these locations was small.

The coefficient for the index of interest in computers was negative and significant. This meant that 15-year olds scoring higher on the interest scale tended to score lower on the PISA reading test. However, the correlation estimate was not very high, with roughly 8 points separating respondents on both sides of the scale. This result could be due to the representativeness of the derived variables based on the questions selected for its composition. The index measuring the perceived ability to use computers was found to be highly correlated with the PISA reading scores. No other ICT related variables obtained a higher level of correlation. Almost two-thirds of a proficiency level (see Box 3.2 in Section III) separated respondents reporting low and high perceived ability. It is important to highlight that the index measures perceived ability as reported by students and that it is not a performance measure of abilities. It has been proposed that in 2006, PISA will test computer skills, which would allow for further testing of the effect of computer abilities on reading and math scores.

The two gender interaction variables were negatively correlated. However, only the index of perceived computer ability was significant when it interacted with gender. The results of the estimation suggest that the higher perceived ability to use computers is more beneficial for boys than girls. Given the fact that the overall PISA scores were higher for girls than boys, perceived ability to use computers may reduce the gender gap in reading scores. Alternatively, boys may report higher computer ability than girls regardless of ability.

The types of computer usage variables could be categorized into two categories: reading oriented and math oriented. Reading oriented use included variables measuring the use of word-processing software and e-mailing. Both variables were positively correlated with reading skills. For example, a respondent reporting very frequent use of word-processing software on average scored over 36 points higher in reading than a respondent reporting no such use. Mathematics oriented use included computer programming, the use of spreadsheets, and computer graphics. All three variables were negatively correlated. For example, respondents reporting no computer programming on average scored almost 36 point higher on the PISA reading test than respondents reporting very frequent computer use of this type. If ICT skills are tested on PISA 2006, their effect on math scores could be analysed and may be found to be different from the effect on reading scores.

The coefficient for the use of educational software was negative and significant. Although puzzling, there is a plausible explanation. The negative correlation with reading scores might be explained by the fact that respondents experiencing educational challenges might be more inclined to use such software on a frequent basis in order to overcome these problems.

The frequency of using computers for playing games and accessing the Internet were not significantly correlated with reading skills as measured by PISA. However, in terms of games it is important to note that only computer games were represented by this variable.

The results presented in this section suggest that certain aspects of computer use are associated with reading skills over and above family and individual variables. However, certain individual variables such as enjoyment of reading (29 points) and family educational support (-20 points) had much higher estimates of correlation (see appendix C). Of the seventeen ICT variables tested in the models, only a few had significant effects. The perceived ability to use computers was the most highly correlated ICT variable used in the study, and it also potentially lowered the gender gap in reading scores.

When only looking at individual, family and provincial characteristics 32.4% of the variation in PISA reading scores was explained by the basic model. By adding the information on ICT available from PISA, the explanatory power of the model increased to 37.3%, an increase of five percent. Although the five models were able to explain about a third of the variation in PISA reading scores, still they could not account for many characteristics of ICT users. More research is needed to account for some of the results obtained in these analyses.

Section VII
Conclusion and policy implications

The effect of computers and the Internet on students' performance has been an open question for researchers. Research done so far has painted a mixed picture of the effects of ICT, with some finding a positive link, no link at all, or even negative ones. The emerging evidence suggests that access to these technologies is not as important as the quality of its use.

Findings from this study showed that a vast majority of 15-year-old Canadians had access to computers at their homes, schools, and libraries. Canada compared well internationally with other countries, with 88% of 15-year olds having access to a computer at home, which was above the OECD average (73%). Most of the youth used computers on a daily basis. Access to the Internet was also reported by a majority of respondents and the frequency of its usage was also very high. Some significant gender and provincial differences were discovered in terms of access and usage of both computers and the Internet.

Bivariate analysis revealed a significant association between PISA reading scores and possessing a computer or an Internet link at home. Students with either of these amenities at home scored half a proficiency level higher than the students without them. Higher reading scores were also associated with frequent use of computers and Internet at home, as well as an infrequent use of computers at school and computer games.

Multivariate analysis indicated that over and above family and individual characteristics, only a few ICT variables obtained significant correlations with PISA reading scores. Home computer access was positively related with reading skills, but on the other hand, using computers often in libraries was negatively related. However, since 88% of 15-year olds had computers at home, the number of students relying exclusively on access in libraries is likely to be small. Among the different types of computer-use variables tested, the perceived ability to use computers was the most highly correlated ICT variable. It may moderate the gender gap in reading skills, however, this finding should be cautiously interpreted, as perceived ability is self-reported and not measured.

Policy Implications

Computers have affected almost every part of our everyday lives, ranging from the labour market to personal activities. Directly or indirectly, the use of computers at school as well as at home will impact learning, and this trend will most likely continue into the future. By the time these youth enter the labour force, ICT literacy might no longer be a specialized skill (except for specific applications), but rather a necessary one for a successful career.

As shown in this report, the ICT penetration rates for 15-year old youth in Canada are very high. Therefore, it is impossible to calculate the true premium obtained from having access to computers and the Internet in Canada. Given this fact, research should focus on specific ICT factors in order to account for the impact of computers on individuals' reading skills.

This analysis indicates that efforts should shift from providing access to increasing the use of Information and Communication Technologies in ways that are productive for learning and its application in the economy and society. For example, reading related computer use proved to be beneficial for reading skills.

In 2000, Canadian 15-year-olds ranked second among 32 OECD countries in reading scores, as well as second on an index of perceived ability of computer skills (OECD, 2001). Canada's Innovation Strategy calls for Canada to become one of the top three countries in mathematics, science and reading, as well as computer and Internet literacy by the end of grade school (Human Resources Development Canada, 2002). Given that there exists a clear link between reading scores and perceived computer abilities, the high ranking in those two measures are important for maintaining international competitiveness.

Students participating in the Programme for International Student Assessment in 2000 also took part in the Youth in Transition Survey (YITS). YITS is a longitudinal survey which will be administered to the same group of respondents every two years until they are in their late twenties. The longitudinal data from the survey will allow the examination of the impact of computer abilities, and computer use in 2000, on the future trajectories of these youth. It will be possible to study the effect of ICT on their post-secondary education success and their labour market outcomes.

Section VIII
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Appendix A

Table 4.1.1
Percentage of 15-year-olds reporting home computer and Internet access, by province and gender

	Computer	Internet
OECD	**73.0**	**44.0**
Newfoundland and Labrador	76.2	55.1
Prince Edward Island	81.3	59.1
Nova Scotia	83.9	67.7
New Brunswick	77.3	61.7
Quebec	79.6	59.3
Ontario	93.0	77.3
Manitoba	85.0	62.4
Saskatchewan	87.1	63.7
Alberta	90.0	73.6
British Columbia	92.9	76.1
CANADA	**87.9**	**70.2**
Females	86.7	68.3
Males	89.1	72.1

Table 4.1.2
Percentage of 15-year-olds reporting frequency of computer access at school and library of less than once a month or never

	School	Library
Newfoundland and Labrador	7.2	20.3
Prince Edward Island	8.2	16.6
Nova Scotia	12.4	20.6
New Brunswick	18.1	31.3
Quebec	26.6	41.2
Ontario	7.3	13.6
Manitoba	6.8	17.8
Saskatchewan	4.8	15.5
Alberta	4.3	14.7
British Columbia	10.2	16.6
CANADA	**12.1**	**21.5**
Females	11.9	19.5
Males	12.4	23.5

Table 4.2.1
Reported frequency of computer usage at home by 15-year-olds, by province and gender, percentage

	Every day	Few times/ week	1 - 4/month	<1/month	Never
Newfoundland & Labrador	48.7	15.6	7.3	4.3	24.2
Prince Edward Island	44.3	20.5	9.8	4.3	21.1
Nova Scotia	55.8	16.5	7.0	3.5	17.3
New Brunswick	46.1	18.4	7.6	3.6	24.3
Quebec	42.2	20.8	9.3	5.5	22.3
Ontario	58.9	20.8	9.3	3.3	7.7
Manitoba	45.5	22.8	10.8	4.9	16.0
Saskatchewan	45.9	23.3	11.7	4.7	14.4
Alberta	50.4	23.1	11.0	4.2	11.2
British Columbia	52.7	23.4	10.6	4.3	8.9
CANADA	51.6	21.3	9.6	4.2	13.3
Females	45.3	23.5	11.9	4.8	14.5
Males	57.9	19.0	7.4	3.6	12.1

Table 4.2.2
Reported frequency of computer usage at school by 15-year-olds, by province and gender, percentage

	Every day	Few times/ week	1 - 4/month	<1/month	Never
Newfoundland & Labrador	21.3	28.8	22.1	19.6	8.3
Prince Edward Island	25.6	17.2	21.4	19.2	16.6
Nova Scotia	16.6	20.1	25.2	21.6	16.5
New Brunswick	14.3	13.8	24.8	26.4	20.6
Quebec	5.3	21.2	20.4	26.6	26.5
Ontario	24.3	19.6	22.8	21.5	11.8
Manitoba	28.7	24.4	22.1	15.9	9.0
Saskatchewan	27.5	23.9	22.6	17.8	8.1
Alberta	22.4	26.1	27.4	17.0	7.2
British Columbia	13.9	21.2	23.4	23.6	17.9
CANADA	**18.1**	**21.2**	**22.9**	**22.2**	**15.6**
Females	15.1	18.9	23.2	25.0	17.8
Males	21.1	23.6	22.6	19.4	13.4

Table 4.2.3
Reported frequency of computer usage at libraries by 15-year-olds, by province and gender, percentage

	Every day	Few times/ week	1 - 4/month	<1/month	Never
Newfoundland & Labrador	5.0	11.6	20.4	26.7	36.3
Prince Edward Island	5.4	7.6	18.8	28.1	40.1
Nova Scotia	4.5	8.2	19.5	29.7	38.0
New Brunswick	2.8	5.8	16.5	28.9	46.0
Quebec	2.2	4.8	12.4	23.9	56.7
Ontario	5.0	10.9	24.5	31.3	28.2
Manitoba	6.2	12.3	22.8	28.6	30.0
Saskatchewan	5.7	12.5	25.7	29.7	26.4
Alberta	5.4	11.1	25.6	29.9	28.0
British Columbia	4.3	9.0	22.5	30.8	33.3
CANADA	**4.3**	**9.2**	**21.1**	**29.0**	**36.4**
Females	3.1	8.1	19.9	31.1	37.7
Males	5.5	10.2	22.2	26.9	35.1

Table 4.2.4
Reported frequency of computer usage at other places by 15-year-olds, by province and gender, percentage

	Every day	Few times/ week	1 - 4/month	<1/month	Never
Newfoundland & Labrador	6.2	16.5	25.1	26.9	25.3
Prince Edward Island	5.9	11.8	23.7	27.3	31.3
Nova Scotia	7.5	15.4	25.4	26.1	25.6
New Brunswick	6.4	12.6	23.3	23.8	34.0
Quebec	4.3	10.2	19.1	23.3	43.2
Ontario	7.1	12.6	23.8	25.6	30.9
Manitoba	6.4	14.2	23.1	24.5	31.8
Saskatchewan	5.9	14.0	21.6	28.5	29.9
Alberta	6.5	13.3	21.6	26.1	32.5
British Columbia	5.0	12.9	23.4	25.4	33.3
CANADA	**6.0**	**12.4**	**22.4**	**25.2**	**34.0**
Females	4.2	9.9	20.0	27.2	38.7
Males	7.8	14.9	24.7	23.2	29.3

Table 4.2.5
Frequency of Internet use by respondents with and without home-Internet access

Frequency	With home-Internet access	Without home-Internet access
Every day	59.5	13.0
Few time / week	26.4	22.5
1-4 / month	10.7	28.4
< 1 / month	2.8	23.7
Never	0.6	12.4

Table 4.3.1
Frequency of different types of computer use, by gender

		Every day	Few times/week	1 – 4/ month	<1/month	Never
Internet	CANADA	46.1	25.2	15.8	8.9	4.1
	Females	40.8	24.9	18.5	10.7	5.0
	Males	51.4	25.5	13	7.0	3.1
Communication	CANADA	38.1	21.9	13.6	10.9	15.5
	Females	36.1	22.7	14.2	11.7	15.3
	Males	40.2	21.0	13.0	10.2	15.6
Help to learn	CANADA	10.3	21.3	27.6	21.1	19.7
	Females	8.7	20.9	28.9	22.4	19.0
	Males	11.8	21.7	26.3	19.8	20.5
Programming	CANADA	11.3	15.5	16.8	20.1	36.3
	Females	6.3	11.7	16.1	22.6	43.3
	Males	16.4	19.3	17.5	17.6	29.2
Games	CANADA	21.4	26.2	22.4	18.0	12.0
	Females	9.9	21.3	25.6	25.5	17.7
	Males	32.9	31.2	19.1	10.4	6.3
Word processing	CANADA	17.4	34.4	30.2	11.5	6.5
	Females	16.4	35.4	31.4	11.4	5.5
	Males	18.5	33.4	28.9	11.6	7.6
Spreadsheets	CANADA	6.0	14.6	23.9	25.5	30.0
	Females	5.4	13.3	22.6	25.8	32.8
	Males	6.6	15.9	25.1	25.1	27.2
Drawing	CANADA	8.9	17.9	24.4	26.3	22.6
	Females	6.5	16.1	24.7	28.8	24.0
	Males	11.4	19.7	24.0	23.8	21.1
Educational software	CANADA	4.7	12.8	24.2	27.8	30.4
	Females	4.5	12.6	24.9	28.0	30.1
	Males	4.9	13.1	23.6	27.6	30.8

Table 4.4.1 The comfort level with using computers, by provinces				
	Very comfortable	**Comfortable**	**Somewhat comfortable**	**Not comfortable**
Newfoundland and Labrador	61.9	26.0	9.9	2.2
Prince Edward Island	60.4	28.0	9.1	2.4
Nova Scotia	62.2	27.2	8.7	1.9
New Brunswick	63.3	25.2	9.4	2.2
Quebec	62.1	23.8	11.2	2.9
Ontario	65.7	24.6	8.3	1.4
Manitoba	63.3	26.0	9.2	1.4
Saskatchewan	61.8	27.1	8.9	2.3
Alberta	62.5	27.0	8.2	2.3
British Columbia	58.9	28.4	10.2	2.5
CANADA	**63.1**	**25.5**	**9.3**	**2.1**
Females	53.4	32.0	12.3	2.3
Males	72.9	18.9	6.4	1.8

Table 4.4.2 Percentage of 15-year-olds to whom working with computers is either important or not important, by province and gender		
	Important	**Not Important**
Newfoundland and Labrador	65.1	34.9
Prince Edward Island	59.7	40.3
Nova Scotia	65.9	34.1
New Brunswick	60.4	39.6
Quebec	53.9	46.1
Ontario	71.2	28.8
Manitoba	63.5	36.5
Saskatchewan	61.1	38.9
Alberta	63.2	36.8
British Columbia	64.2	35.8
CANADA	**64.2**	**35.8**
Females	58.4	41.6
Males	70.0	30.0

Appendix B

Table 5.1.1
PISA reading scores by number of reported computers at home, by province

	No	Standard Error	One	Standard Error	Two	Standard Error	Three+	Standard Error
Newfoundland and Labrador	480	4.0	527	3.7	543	7.6	547	18.7
PEI	486	5.3	524	3.1	536	6.8	534	10.4
Nova Scotia	486	6.2	523	2.5	540	4.9	571	10.8
New Brunswick	464	4.0	509	2.4	524	5.0	537	10.1
Quebec	507	4.0	541	3.3	551	4.3	561	7.0
Ontario	471	10.7	527	3.1	550	3.6	563	6.2
Manitoba	481	7.2	535	3.5	544	6.2	570	10.0
Saskatchewan	490	7.3	532	2.7	545	4.4	542	8.1
Alberta	496	7.3	547	3.1	568	5.0	587	6.6
British Columbia	488	7.5	536	3.6	551	3.7	560	6.5
CANADA	**491**	**3.1**	**534**	**1.5**	**551**	**2.0**	**564**	**3.5**

Table 5.1.2
PISA reading scores by number of reported computers at home, by gender

	No	Standard Error	One	Standard Error	Two	Standard Error	Three+	Standard Error
Females	509	3.4	551	1.8	567	2.5	580	4.9
Males	468	3.7	515	1.8	537	2.6	553	4.3
CANADA	**491**	**3.1**	**534**	**1.5**	**551**	**2.0**	**564**	**3.5**

Table 5.1.3
PISA reading scores by reported home Internet access, by province and gender

	Internet	Standard Error	No Internet	Standard Error
Newfoundland and Labrador	538	3.7	495	3.8
PEI	527	3.5	507	3.8
Nova Scotia	536	2.4	496	4.7
New Brunswick	518	2.7	477	2.8
Quebec	550	3.6	518	3.1
Ontario	543	3.1	504	5.5
Manitoba	540	3.7	515	5.4
Saskatchewan	538	2.6	515	4.8
Alberta	563	3.5	521	4.9
British Columbia	548	3.0	511	4.3
CANADA	**546**	**1.6**	**510**	**2.1**
Females	562	1.9	528	2.2
Males	531	1.9	489	2.7

Table 5.2.1
PISA reading scores by the frequency of home computer use, by province and gender

	Every day	Standard Error	Few times/week	Standard Error	1 – 4/month	Standard Error	<1/month	Standard Error	Never	Standard Error
Newfoundland and Labrador	533	3.7	531	6.2	530	10.1	504	15.0	479	4.6
PEI	526	3.9	529	5.5	542	6.8	518	11.9	485	5.0
Nova Scotia	533	2.6	530	5.6	540	8.3	489	10.6	481	5.4
New Brunswick	520	2.9	512	4.0	513	6.4	487	9.8	467	4.0
Quebec	548	3.8	547	4.1	541	5.0	532	6.8	508	3.6
Ontario	543	3.1	535	4.3	539	5.3	500	8.9	474	9.1
Manitoba	540	4.5	540	4.5	547	7.3	538	9.7	482	7.3
Saskatchewan	537	3.0	540	3.5	537	5.8	515	9.4	488	6.5
Alberta	563	4.2	559	4.1	553	6.3	515	8.1	496	6.2
British Columbia	550	3.3	543	4.7	539	5.4	514	10.6	481	6.4
CANADA	**545**	**1.6**	**541**	**2.1**	**541**	**2.4**	**515**	**3.3**	**491**	**2.7**
Females	560	2.1	561	2.3	560	3.7	533	4.2	510	2.9
Males	534	2.0	516	2.9	509	3.8	492	5.4	468	3.4

Table 5.2.2
PISA reading scores by the frequency of Internet use, by province and gender

	Every day	Standard Error	Few times/week	Standard Error	1 – 4/month	Standard Error	<1/month	Standard Error	Never	Standard Error
Newfoundland and Labrador	529	4.3	512	5.9	516	5.8	515	8.1	454	13.1
PEI	520	4.0	527	5.5	520	5.1	515	7.4	498	14.6
Nova Scotia	530	2.5	523	4.6	519	5.8	502	9.2	470	15.8
New Brunswick	516	3.0	509	3.6	507	4.0	485	5.5	452	9.6
Quebec	547	3.7	538	4.4	543	3.7	526	4.0	510	7.1
Ontario	539	3.5	536	4.0	536	5.6	511	7.7	497	7.9
Manitoba	533	4.5	534	4.8	533	6.4	526	7.9	506	13.5
Saskatchewan	534	3.5	530	4.2	529	5.5	531	6.7	478	13.4
Alberta	559	4.4	546	4.0	560	5.5	531	6.3	484	13.6
British Columbia	545	3.7	544	3.4	538	6.0	531	7.3	492	12.2
CANADA	**542**	**1.8**	**537**	**1.9**	**538**	**2.4**	**521**	**3.0**	**498**	**3.7**
Females	555	2.3	558	2.3	556	3.0	537	3.4	520	4.2
Males	531	2.2	517	2.4	512	3.2	495	4.8	462	7.2

Table 5.2.3
PISA reading scores by the frequency of school computer use, by province and gender

	Every day	Standard Error	Few times/week	Standard Error	1 – 4/month	Standard Error	<1month	Standard Error	Never	Standard Error
Newfoundland	498	6.4	505	4.6	533	4.7	539	6.0	525	9.4
PEI	521	5.2	510	6.1	518	4.7	531	5.8	514	6.6
Nova Scotia	520	5.2	510	4.7	521	5.7	531	5.5	529	5.3
New Brunswick	505	4.7	498	5.2	511	3.7	513	3.6	486	4.3
Quebec	522	6.6	533	3.9	539	4.9	545	3.6	536	4.2
Ontario	530	5.7	531	6.2	541	4.3	542	4.0	522	5.4
Manitoba	531	4.7	527	6.2	541	6.1	529	5.5	519	7.3
Saskatchewan	532	4.7	522	4.7	536	4.0	536	4.7	508	6.9
Alberta	546	4.7	543	5.4	567	4.4	557	4.6	524	9.4
British Columbia	528	7.0	540	5.0	544	5.1	552	3.6	525	5.2
CANADA	**530**	**3.1**	**532**	**2.6**	**542**	**2.0**	**543**	**1.9**	**527**	**2.7**
Females	541	3.4	545	3.6	561	2.6	558	2.3	545	3.1
Males	521	3.7	521	2.9	523	2.6	524	2.8	501	3.4

Table 5.2.4
PISA reading scores by the frequency of playing computer games, by province and gender

	Every day	Standard Error	Few times/week	Standard Error	1 – 4/month	Standard Error	<1/month	Standard Error	Never	Standard Error
Newfoundland and Labrador	497	4.8	514	4.9	539	5.9	532	6.1	517	10.2
PEI	500	5.8	522	4.6	533	5.0	537	4.8	505	9.3
Nova Scotia	508	4.5	523	4.4	534	4.1	535	5.3	516	7.6
New Brunswick	493	5.2	507	3.2	519	4.3	514	3.5	487	4.5
Quebec	528	4.6	537	3.8	541	4.0	553	5.0	537	4.2
Ontario	516	5.7	533	4.3	551	3.9	544	4.7	528	5.9
Manitoba	519	5.8	528	4.2	542	5.1	545	5.3	523	9.8
Saskatchewan	514	5.6	527	4.3	541	4.0	542	4.9	525	6.5
Alberta	539	5.6	549	4.2	562	5.1	570	5.1	541	8.0
British Columbia	532	5.4	536	3.8	545	4.5	553	4.4	539	5.6
CANADA	**522**	**2.8**	**534**	**2.2**	**547**	**1.9**	**549**	**2.3**	**532**	**2.6**
Females	527	4.9	547	3.0	562	2.4	562	2.4	546	2.7
Males	520	2.9	525	2.5	526	2.7	517	4.0	493	5.0

Appendix C

Complete regression results from Section VI (table 6.1.1)

	Model 1		Model 2		Model 3		Model 4		Model 5	
VARIABLE	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**
Intercept term	479.60	4.44	480.72	5.27	483.94	5.16	481.95	5.17	501.06	5.82
Enjoyment of reading	28.47	1.05	28.34	1.05	28.22	1.08	28.13	1.07	26.73	1.11
Time spent on reading	-2.77	0.97	-2.96	0.98	-3.19	0.99	-3.29	0.98	[sn]-2.04	1.05
Diversity of reading material	4.01	0.95	3.92	0.97	3.68	0.99	3.60	0.98	4.15	0.95
Frequency of borrowing books	-6.03	1.07	-4.48	1.13	-4.22	1.12	-4.11	1.11	-3.55	1.08
Time spent on homework	8.33	0.92	8.11	1.06	8.46	0.91	8.27	0.89	8.19	0.85
Sense of belonging to school	[sn]-0.21	0.73	[sn]0.19	0.72	[sn]-0.68	0.71	[sn]-0.58	0.72	[sn]-0.69	0.66
Gender (female = 1)	13.88	1.54	12.52	1.61	14.06	1.66	18.74	1.84	14.19	2.07
Single parent family	-9.87	2.00	-7.53	2.08	-7.18	2.06	-7.44	2.04	-6.54	1.44
Mixed family	-17.88	2.49	-14.69	2.49	-15.15	2.44	-15.22	2.44	-14.52	2.44
Other family type	-23.51	5.10	-20.51	5.24	-20.77	5.19	-20.74	1.56	-21.29	5.20
Number of siblings	-3.20	0.83	-2.75	0.82	-2.56	0.82	-2.57	0.83	-2.63	0.80
Socio-economic status	0.96	0.05	0.85	0.05	0.82	0.05	0.81	0.05	0.73	0.05
Number of books at home	5.25	0.61	4.74	0.60	4.47	0.58	4.44	0.59	3.83	0.57
Home educational resources	4.58	0.80	4.09	0.80	3.99	0.79	3.97	0.78	4.30	0.75
Home cultural possessions	[sn]0.89	0.87	[sn]0.93	0.82	[sn]0.63	0.83	[sn]0.67	0.83	1.69	0.79
Cultural activities	6.12	0.96	6.43	0.97	6.71	0.94	6.80	0.94	6.83	1.00
Family educational support	-20.40	1.05	-19.53	1.05	-19.04	1.08	-18.92	1.08	-17.03	1.06
Cultural communication	6.85	0.93	7.18	0.93	7.12	0.89	7.05	0.89	7.26	0.91
Social communication	2.11	0.82	1.95	0.79	1.67	0.81	1.73	0.80	[sn]1.62	0.81
Official language but different from test	-33.33	4.33	-34.09	4.56	-34.09	4.64	-34.10	4.62	-35.45	4.87
Other language at home	-33.29	3.24	-33.21	3.35	-31.58	3.34	-31.58	3.33	-29.60	3.35
Newfoundland and Labrador	-12.77	3.08	-9.77	3.26	-8.99	3.22	-8.51	3.22	-8.00	3.23
Prince Edward Island	-7.60	3.05	-6.28	2.92	-6.52	2.91	-6.37	2.86	-7.45	2.91
Nova Scotia	-9.96	2.72	-9.21	2.71	-8.20	2.73	-8.01	2.73	-8.34	2.66
New Brunswick	-22.78	2.82	-21.83	2.66	-22.51	2.64	-22.12	2.64	-22.01	2.53
Quebec	17.73	3.12	16.06	3.06	15.81	3.02	15.23	2.99	11.18	2.89
Manitoba	[sn]6.22	3.60	7.85	3.51	7.41	3.47	7.28	3.46	7.60	3.37
Saskatchewan	7.48	3.64	8.33	3.60	8.17	3.52	8.43	3.51	7.91	3.45
Alberta	18.43	3.50	18.95	3.53	18.81	3.51	18.87	3.51	18.80	3.26
British Columbia	[sn]4.32	3.41	[sn]3.9	3.32	[sn]3.94	3.27	[sn]3.88	3.25	[sn]2.07	3.14
Home computer use			5.36	0.54	4.10	1.68	4.06	0.77	3.82	0.75
School computer use			1.28	0.62	0.74	0.28	[sn]0.76	0.63	1.99	0.67
Library computer use			-5.79	0.85	-5.67	-2.34	-5.64	0.85	-3.95	0.83
Other place computer use			-3.83	0.60	-4.15	-1.68	-4.33	0.59	-2.89	0.59
Index of computer interest					-5.46	0.90	-4.08	1.21	-2.60	1.19
Index of computer ability					10.38	0.91	14.82	1.24	17.76	1.33

	Model 1		Model 2		Model 3		Model 4		Model 5	
VARIABLE	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**
Index of computer interest of females							[sn]-2.13	1.53	[sn]-2.04	1.61
Index of computer ability of females							-9.57	1.90	-11.09	1.90
Use of Internet									[sn]-1.47	1.16
Use of e-mail									3.82	0.86
Use of word-processing software									7.32	1.09
Use of computers to learn									[sn]-1.28	0.79
Use of educational software									-5.01	0.87
Computer programming									-7.17	0.68
Computer graphics									-3.35	0.82
Use of spreadsheets									-4.79	0.83
Use of computer games									[sn]-0.85	0.69
R – squared	0.324		0.337		0.344		0.348		0.373	
ns - denotes no statistical significance at 95% level of confidence										

Description of variables used in multivariate analyses

COMPUTER GRAPHICS
How often do you use each of the following kinds of computer software? Drawing, painting or graphics.

COMPUTER PROGRAMMING
How often do you use the computer for programming?

CULTURAL ACTIVITIES
Index of cultural activities.
How often did the student (within last year) visit a museum or art gallery, attended an opera, ballet or classical symphony concert, and watched live theatre.

CULTURAL COMMUNICATION
Index of cultural communication.
Frequencies with which their parents engaged with them in discussing political or social issues, books, films or television programs, and listening to classical music.

DIVERSITY OF READING MATERIAL
Index of reading diversity.
How often do you read the following for enjoyment? Magazines, comic books, fiction, non-fiction, e-mail, WebPages and newspapers.

ENJOYMENT OF READING
Index of reading enjoyment.
I read only if I have to.
Reading is one of my favorite hobbies.
I like talking about books with other people.
I find it hard to finish a book.
I feel happy if I receive a book as a present.
For me reading is a waste of time.
I enjoy going to a bookstore or a library.
I read only to get information that I need.
I cannot sit still and read for more than a few minutes.

FAMILY EDUCATIONAL SUPPORT
Student's report on the frequency of mother, father or brother, sister worked with the students on what is nationally regarded as school-work.

FREQUENCY OF BORROWING BOOKS
How often do you borrow books to read for pleasure from a public or school library?

HOME COMPUTER USE
How often do you use a computer at home?

HOME CULTURAL POSSESSIONS
Index of home cultural possessions.
Student's report on the availability at home of classical literature, books of poetry and works of art.

HOME EDUCATIONAL RESOURCES
Index of home educational resources.
Student's report on the availability at home of a dictionary, a quite place to study, a desk for study, textbooks and calculators.

INDEX OF ABILITY TO USE COMPUTERS
Index of comfort with and perceived ability to use computers.
How comfortable are you with using a computer?
How comfortable are you with using a computer to write a paper?
How comfortable are you with taking a test on a computer?
If you compare yourself with other 15-year-olds, how would you rate your ability to use a computer?
Inverted.

INDEX OF ABILITY TO USE COMPUTERS BY FEMALES
Interaction variable created by combining variables COMAB and GENDER

INDEX OF INTEREST IN COMPUTERS
Index of interest in computers.
It is very important to me to work with a computer.
To play or work with a computer is really fun.
I use a computer because I am very interested in it.
I forget time when I work with a computer.

INDEX OF INTEREST IN COMPUTERS BY FEMALES
Interaction variable created by combining variables COMATT and GENDER

LIBRARY COMPUTER USE
How often do you use a computer in a library?

NUMBER OF BOOKS AT HOME
How many books do you have at home?

NUMBER OF SIBLINGS
Students were asked to indicate the number of siblings older than themselves, younger than themselves and of the same age live with them. Those were added.

OTHER PLACE COMPUTER USE
How often do you use a computer at other places?

USE OF COMPUTER GAMES
How often do you use each of the following kinds of computer software? Games.

SCHOOL COMPUTER USE
How often do you use a computer at school?

SENSE OF BELONGING TO SCHOOL
Index of sense of belonging to school.
My school is a place where I: feel like outsider, make friends easily, feel like I belong, feel awkward, other students like me, feel lonely, do not want to go, often feel bored.

SOCIAL COMMUNICATION
Index of social communication.
Frequencies with which their parents engaged with them in discussing how well they are doing in school, eating with them around a table, spending time simply talking with them.

SOCIO-ECONOMIC STATUS
Index of highest socio-economic status.
Derived from student's report of parental occupational attainment, in case of two parents with different index value, the higher was reported.

TIME SPENT ON HOMEWORK
Time spent on homework.

TIME SPENT ON READING
Each day, about how much time do you usually spend reading for enjoyment?

USE OF COMPUTERS TO LEARN
How often do you use the computer to help you learn school material?

USE OF EDUCATIONAL SOFTWARE
How often do you use each of the following kinds of computer software? Educational software.

USE OF E-MAIL
How often do you use a computer of electronic communication (e.g. e-mail or "chat rooms")?

USE OF INTERNET
How often do you use the Internet?

USE OF SPREADSHEETS
How often do you use each of the following kinds of computer software? Spreadsheets (e.g. Lotus 1 2 3, or Microsoft Excel).

USE OF WORD PROCESSING SOFTWARE
How often do you use each of the following kinds of computer software? Word processing (e.g. Word or Word Perfect)?

Dummy Variables

NEWFOUNDLAND AND LABRADOR
Dummy variable representing the province of Newfoundland and Labrador

PRINCE EDWARD ISLAND
Dummy variable representing the province of Prince Edward Island

NOVA SCOTIA
Dummy variable representing the province of Nova Scotia

NEW BRUNSWICK
Dummy variable representing the province of New Brunswick

QUEBEC
Dummy variable representing the province of Quebec

MANITOBA
Dummy variable representing the province of Manitoba

SASKATCHEWAN
Dummy variable representing the province of Saskatchewan

ALBERTA
Dummy variable representing the province of Alberta

BRITISH COLUMBIA
Dummy variable representing the province of British Columbia

Note: Ontario was not included in the regression and therefore the estimates for the provincial dummies should be interpreted with respect to Ontario.

SINGLE PARENT FAMILY
Dummy variable representing respondents living in a single parent household

MIXED PARENT FAMILY
Dummy variable representing respondents living in a mixed family

OTHER FAMILY TYPE
Dummy variable representing respondent lining in other types of family structure

Note: Nuclear family was not included in the regression and therefore the estimates for the family type dummies should be interpreted with respect to a nuclear family type.

GENDER
Dummy variable representing respondents gender

Note: Boys were not included in the regression and therefore the estimates for the gender dummy should be interpreted with respect to boys.

OFFICIAL LANGUAGE AT HOME BUT DIFFERENT AT TEST
Dummy variable representing respondents whose language used at home is one of the official languages but different from the language in which the assessment was conducted

OTHER LANGUAGE AT HOME

Dummy variable representing respondents whose language used at home is other than the official languages.

Note: Respondents whose home language is one of the official languages and the same as that of the assessment were not included in the regression and therefore the estimates for the language dummies should be interpreted with respect to the omitted group.