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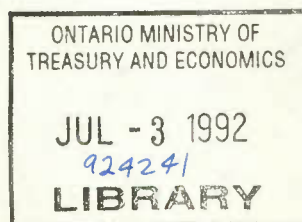
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**International and Interprovincial
Comparisons of
Student Cognitive Achievement**

Thomas T. Schweitzer



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International and Interprovincial Comparisons of Student Cognitive Achievement

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Foreword

To meet increasing global competition, Canada's quest for productivity improvement must focus on technological advance and the skill needs of the knowledge economy. Education and training will thus be a cornerstone of any long-run strategy for economic development. Accordingly, the Economic Council of Canada has undertaken a study of this complex and controversial field. The analysis considers a variety of topics concerned with quality and the efficiency of resource allocation in the education and training system.

Until recently we had little information on Canadian academic achievement as compared to that of other countries. Also, inter-provincial assessment has been extremely rare in Canada. This paper brings together what is currently available, in a way accessible to provincial and federal policy makers. It also attempts to adjust the data for years of schooling and for the selectivity of the various national and provincial school systems. The author, Thomas T. Schweitzer, is senior economist on the staff of the Council.

Judith Maxwell
Chairman

The Purpose of This Paper

The evaluation of the quality of our educational system is a difficult task. One of the many criteria that must be investigated is how the cognitive achievement of our students compares with that of their counterparts in other countries.

Measures of cognitive achievement attempt to assess what the students know. The results can be regarded as indicators of the students' level of knowledge and of their ability to acquire and apply knowledge — an important aspect of the individual's productivity in the information- and technology-intensive economy of our age.

The evidence on the cognitive achievement of Canadian students is fragmentary and not easy to evaluate in a consistent and valid manner. In this paper we shall attempt to pull together the available data. We think that a reasonably clear picture is beginning to emerge when we put the stones of the mosaic together.

The Sources

Our data sources for international and interprovincial comparisons of student cognitive achievement are the following.

- 1) The International Association for the Evaluation of Education Achievement (IEA) Second International Mathematical Study (SIMS) (1980-82), (Robitaille, David F. and Robert A. Gordon, 1989; Robitaille, David F., 1990)
- 2) The IEA Second International Science Study (SISS) (1983-1986), (International Association for the Evaluation of Educational Achievement, 1988; Crocker, Robert K., 1990)
- 3) The Educational Testing Service (ETS) report on the first International Assessment of Educational Progress entitled *A World of Differences* (1988). This study assessed student achievement in the mathematics and in science (separately), (Lapointe, Archie E. *et al*, 1989; Quebec, Ministère de l'Éducation, 1989)
- 4) The second International Assessment of Educational Progress, reporting on student achievement in mathematics (*Learning Mathematics*, 1992) and in science (*Learning Science*, 1992) (Lapointe, Archie E. *et al*, 1992a; 1992b)

- 2 International and Interprovincial Comparisons of
- 5) The National Geographic Survey of geographic knowledge (1988-89),
(The Gallup Organization, 1988; 1989)
- 6) The Southam Literacy Survey (1987) (Southam News, 1987), and
- 7) Einsiedel Survey of Scientific Literacy (1990) (Einsiedel, Edna F. 1990).

ANALYSIS AND RESULTS

Second International Mathematics Study (SIMS)

The purpose of SIMS was to learn about, and improve on, the teaching of primary and secondary school mathematics in the participating countries. SIMS was the successor of the First International Mathematical Study (1964). No Canadian province did participate in the First Study. British Columbia and Ontario participated in SIMS. SIMS investigated, among other things, the mathematical achievement of two groups of students in the participating countries.

Population A consisted of a stratified random sample of all students in the grade where the majority have attained the age between 13 years to 13 years 11 months by the middle of the school year (predominantly grade 8).

Population B consisted of all students who were in the normally accepted terminal grade of the secondary education system and who were studying mathematics as a substantial part of their academic program. A note was added to the population B definition indicating that the mathematics course or courses taken by students should involve approximately 5 hours per week of class time.

SIMS was a very large-scale international effort. While a central coordinating organization was, of course, indispensable, much work was done, and much discretion had to be permitted, to the individual participating systems (We use the term "system" rather than "country" because this term is better applicable to the Canadian provinces or the Flemish and French Belgian systems).

A set of test instruments was drawn up, and internationally agreed on, as essentially appropriate for the testing of the populations A and B respectively. We have thus a set of inter-systemic comparisons which can be reasonably expected to be valid. However, as we shall see, great caution has to be exercised, nevertheless.

Population A (Age 13)

20 systems participated in the Population A part of the study. Three of these (Nigeria, Swaziland and Thailand) cannot be regarded as industrialized countries. One (Luxembourg) displayed very special characteristics (very heavily agricultural). In the discussion of Population A results we shall omit these four systems and restrict ourselves to the remaining sixteen, namely

Belgium (French)
 Belgium (Flemish)
 Canada (British Columbia)
 Canada (Ontario)
 England and Wales
 Finland
 France (did not participate in Population B study)
 Hong Kong
 Hungary
 Israel
 Japan
 Netherlands (did not participate in Population B study)
 New Zealand
 Scotland
 Sweden
 United States

Even though schooling is compulsory at age 13 years to 13 years 11 months in almost all industrialized countries, and mathematics is compulsory at this age in all systems, several caveats are indicated.

- Japan and Hong Kong judged the test material as too easy for grade 8. They administered the test to grade 7.
- While in most countries compulsory schooling begins at age 6, in the Scandinavian countries it begins at age 7.

It follows, therefore, that Population A students of Japan, Hong Kong and of the Scandinavian countries had one year less schooling than those of the other systems. Our attempt to adjust the test scores of Population A for years of schooling was unsuccessful, because some systems applying the test to students with seven years of schooling proved to be among the highest scoring systems (like Japan) as well as among the lowest scoring ones (like Sweden).

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SIMS reported scores (per cent correct) for each system, separately, for arithmetic (46 problems), algebra (30 problems), geometry (39 problems) measurement (24 problems), and descriptive statistics (18 problems). A weighted average of the system scores yields the following raw results.

	Per Cent Correct
1) Japan	61.9
2) Netherlands	56.7
3) Hungary	55.6
4) Belgium (Flemish)	53.2
5) France	52.6
6) <i>Canada (B.C.)</i>	51.5
7) Belgium (French)	51.4
8) <i>Canada (Ont.)</i>	49.2
9) Hong Kong	49.0
10) Scotland	48.3
11) England and Wales	47.4
12) New Zealand	47.2
13) Finland	46.7
14) USA	45.3
15) Israel	45.1
16) Sweden	41.8
International mean	50.2

The following results are noteworthy;

- Japan leads by a wide margin,
- the Canadian systems are close to the median and the international mean, with B.C. outperforming Ontario,
- the USA is performing quite poorly.

Population B (end of high school)

As mentioned before, of the 16 industrialized systems participating in the Population A study, two (France and the Netherlands) did not participate in the Population B Study. We are left, therefore, with 14 industrialized countries for this part of our investigation.

If caution is indicated for international comparisons of achievement by Population A, even more is it needed for Population B. This is due to several reasons.

- a) The definition of "terminal grade of secondary education" differs from country to country. For most systems it corresponds to grade 12. For England and Wales, Ontario, and parts of the Hong-Kong and Swedish systems it is grade 13, while in the Scottish system it is partly grade 11 and partly grade 12.
- b) The First International Mathematical Study, in which no Canadian province participated, strongly suggested that the retention rate has a pronounced negative effect on average achievement of the system. In other words, the higher the percentage of an age cohort that completes high school, the lower its average achievement. Among the 14 systems the percentage of the age group still in school by the terminal grade of secondary education ranges from 92 per cent (Japan) to 17 per cent (England and Wales, and New Zealand).
- c) In the last year of high school, 5 hours of mathematics is not compulsory in all systems. Here, too, it is plausible to assume that only those students will voluntarily take mathematics, who are relatively strong in this subject. A more selective system is likely to yield stronger achievement. Population B as per cent of the grade group ranged from 100 per cent (Hungary, where mathematics was compulsory in grade 12) to 10 per cent (Israel).

The joint effect of varying retention rates in the last year of high school and of studying mathematics at least 5 hours per week yields the Population B overall mathematics retention rate as percentage of the age group. This ranged from 50 per cent (Hungary) to six per cent (England and Wales, Hong Kong, and Israel).

The test instruments for Population B covered six areas: sets, relations, functions (seven items), number systems (17 items), algebra (26 items), geometry (26 items), elementary functions and calculus (46 items), and probability and statistics (7 items). The raw weighted achievement ratios of Population B were

1) Hong Kong	72.7
2) Japan	68.4
3) England and Wales	58.8
4) Finland	58.1
5) Sweden	55.0
6) New Zealand	51.1
7) Belgium (Flemish)	49.8
8) <i>Canada (Ontario)</i>	48.8
9) Israel	46.1
10) Belgium (French)	45.7

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11) Scotland	40.0
12) USA	35.7
13) <i>Canada (B.C.)</i>	33.2
14) Hungary	31.7

For reasons mentioned above, the raw achievement ratios are not reliable indicators of the quality of the school systems. It is desirable to purify the raw results of the effect of years of schooling and of the selectivity effect. We have attempted to do this by regressing the raw scores on the years of schooling and the retention ration and adjusting the raw scores accordingly. (For details see Appendix A) The adjusted Population B achievement ratios were

1) Japan	67.5
2) Hong Kong	64.7
3) Finland	59.0
4) Hungary	53.3
5) Sweden	50.5
6) New Zealand	49.6
7) Belgium (Flemish)	47.7
8) Scotland	47.6
9) England and Wales	47.2
10) <i>Canada (Ontario)</i>	44.9
11) Belgium (French)	43.7
12) <i>Canada (B.C.)</i>	42.9
13) Israel	41.7
14) USA	34.8
International mean	49.7

Note the following results, after adjustment for years of schooling and selectivity:

- Japan and Hong Kong are the strongest performers.
- The Canadian provinces are below the median and the mean. The weak performance of B.C. is due to the fact that calculus was not included in its curriculum in those days (this has been changed since then). In number systems, algebra, geometry, probability and statistics, B.C. was outperforming Ontario. Our adjustment for years of schooling and retention rates has somewhat lowered Ontario's international standing and slightly improved that of B.C.
- The USA performance is very weak.

- The adjustment for years of schooling and retentivity makes for some big changes between raw and adjusted results. For instance, England and Wales drops from third place to ninth; Hungary rises from 14th to fourth; the substantial difference in the raw scores of the two Canadian systems is radically reduced after adjustment.

Summary of SIMS Results

The performance of the two participating Canadian provinces was mediocre at the Population A level and worse than mediocre at the Population B level. Our preliminary investigation, not reported here in detail, suggests that this is partly due to the fact that the Canadian curriculum (opportunity to learn) was less rich than that of many other systems. This was particularly true for the absence of calculus in the B.C. grade 12 curriculum. We understand that this has been remedied in the recent revision of the B.C. curriculum. It will be interesting to see whether and how this change will impact the B.C. performance in the forthcoming Third International Mathematics Study.

Second International Science Study (SISS)

SISS was the science counterpart of SIMS. All the anglophone schools of Canada participated immediately in SISS, and soon after the franco-phone schools, including those of Quebec, also administered the test instruments.

SISS tested students in three age groups. Population 1 represented students of approximately 10 years of age (grade 5 in Canada), Population 2 of approximately 14 years (grade 9 in Canada), and Population 3 students taking the highest level high school course in science (biology, chemistry and physics).

Population 1 (Age 10)

Sixteen systems participated at the Population 1 level. We shall restrict our discussion to the 15 we regard as "industrialized", and shall exclude the Philippines. The test was a so-called "core test" of 24 items covering general science appropriate to the age level of the students.

1-2) Japan	64.2
1-2) Korea	64.2
3) Finland	63.8
4) Sweden	61.3
5) <i>Canada (French)</i>	60.4
6) Hungary	60.0

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7)	<i>Canada (English)</i>	57.1
8)	Italy	55.8
9)	USA	55.0
10)	Australia	53.8
11)	Norway	52.9
12)	Poland	49.6
13)	England	48.8
14-15)	Singapore	46.7
14-15)	Hong Kong	46.7
	International mean	56.0

Some noteworthy results of Population 1.

- The Far-Eastern systems occupy the highest (Japan, Korea) as well as the lowest (Singapore, Hong Kong) position.
- Canada, particularly French Canada, is doing reasonably well. As we shall see later, this is due to Quebec's strong showing. French students in other provinces are much weaker.
- At this level the USA achievement is close to the international average.

Population 2 (Age 14)

The test of Population 2 (approx. 14 years old) consisted of a core test of 30 items covering "general science". Eighteen (18) systems participated, but we shall report on the 16 industrialized systems (omitting Thailand and the Philippines). The percentage of correct answers were

1)	Hungary	72.3
2)	Japan	67.3
3)	Netherlands	66.0
4)	<i>Canada (English)</i>	62.0
5)	Finland	61.7
6)	Sweden	61.3
7-8)	Korea	60.3
7-8)	Poland	60.3
9)	<i>Canada (French)</i>	60.0
10)	Norway	59.7
11)	Australia	59.3
12-13)	England	55.7
12-13)	Italy	55.7
14-15)	USA	55.0
14-15)	Singapore	55.0
16)	Hong Kong	54.7
	International mean	60.6

Main results of Population 2

- Wide dispersion of Far-Eastern systems (Japan 2nd, Korea 7-8th, Singapore 13-14th, Hong Kong 15th).
- English Canada doing reasonably well, French Canada has retreated below the median. This is partly due to the very weak performance of French students outside Quebec. (Quebec French students scored 61.0, French outside Quebec 52.3).
- By age 14 the USA is well below the international mean.

Population 3, (End of high school)

Population 3 was tested in Biology, Chemistry or Physics (30 items), according to their taking these courses in high school, also a core test of 30 items was administered to each participant, irrespective of the subject tested.

We report here the results of 15 systems. Hong Kong administered and reported on the test to Form 6 students (who attended the Chinese system of Hong Kong) and to Form 7 (who attended the English system). We shall regard these as two separate systems. The raw data yielded

1) Hong Kong (Form 7)	71.6
2) England	68.3
3) Singapore	66.2
4) Hong Kong (Form 6)	63.4
5) Hungary	61.3
6) Japan	57.5
7) Poland	55.7
8) Norway	55.0
9) Australia	53.1
10) Sweden	52.3
11) Finland	47.4
12) <i>Canada (English)</i>	46.7
13) Italy	41.6
14) USA	40.6
15) <i>Canada (French)</i>	36.0

As in the case of SIMS, the raw data is misleading. The target population 3 of England, Hong Kong Form 7, Singapore, Italy, part of English Canada (Ontario) and part of Sweden received 13 years of schooling, the bulk of French Canada (Quebec) 11 years, all other systems 12. The retention rate of the various systems varied tremendously. In biology it ranged

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from 45 per cent (Finland) to three per cent (Hungary and Singapore); in Chemistry from 37 per cent (Canada French) to one per cent (Hungary and USA); in Physics from 35 per cent (Canada French) to one per cent (USA). Analogously to our adjustment of the raw data of Population B in SIMS, we adjusted the SISS data of SISS Population 3. (For details see Appendix B).

The adjusted scores were

1) Hong Kong (Form 7)	65.1
2) Hong Kong (Form 6)	64.5
3) England	59.5
4) Hungary	59.3
5) Japan	59.0
6) Norway	57.6
7) Singapore	57.4
8) Poland	55.9
9) Australia	54.9
10) Finland	52.9
11) Sweden	52.0
12) <i>Canada (French)</i>	49.8
13) <i>Canada (English)</i>	49.6
14) USA	45.2
15) Italy	35.0
International mean	54.5

Noteworthy are

- the excellent performance of Hong Kong
- the good, but not outstanding performance of Japan (its very good score in the core test is offset by relatively poor performance in Biology)
- the mediocre score of Singapore
- the poor showing of Canada (both English and French)
- the very weak USA performance
- the last place of Italy (ascribed to the predominantly humanistic education prevailing in that system).

Note also that the adjustment caused some important changes between raw and adjusted ranking. Singapore moved down from third to seventh position, Canada (French) was, after adjustment, doing about as well as

Canada (English). Both Canadian systems were ranking very low by international standards.

Interprovincial comparisons of SISS

All Canadian provinces participated in SISS and the provincial samples were big enough to permit valid interprovincial comparisons. In addition to the percentage of correct answers we shall also report the West to East rank correlation of the provinces. We do so because this measure showed up with a high — though not perfect — consistency in the various studies. We do not have an explanation for this phenomenon, but we think it deserves investigation in future research work (see also Schweitzer, 1992)

Population 1 (Age 10)

Core test, percentage correct

1-2	Manitoba	62
1-2	Saskatchewan	62
3	Quebec	60.5
4-5	British Columbia	60
4-5	Alberta	60
6	Prince Edward Island	57
7-8	Ontario	55
7-8	Nova Scotia	55
9	New Brunswick	53
10	Newfoundland	51
	International mean	56

West to East rank correlation = $+0.68$ $p < .05$

6 Canadian provinces outscore the mean of the industrialized countries calculated above. Manitoba and Saskatchewan would outrank all except Japan, Korea and Finland. Even the weakest province (Newfoundland) outscores Poland, England, Hong Kong and Singapore.

Population 2 (Age 14)

Core test, percentage correct

1)	Alberta	66
2)	Nova Scotia	65
3)	British Columbia	63
4)	Manitoba	62
5-6-7)	Saskatchewan	61

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5-6-7)	Ontario	61
5-6-7)	Quebec	61
8)	New Brunswick	59
9-10)	Prince Edward Island	56
9-10)	Newfoundland	56
	International mean	60.4

West to East rank correlation $+0.59$ $p < .10$

Alberta and Nova Scotia outscore all industrialized systems of SISS in Population 2. Even the weakest provinces rank with England and Italy, and outscore Singapore USA, and Hong Kong.

Population 3 (End of high school)

As in the case the international comparisons, the interprovincial comparison of raw results is not justified. Recall that the last year of Ontario is grade 13 and that of Quebec is grade 11. Also, retention rates differ substantially from province to province. For Biology the retention rate ranges from 46.1 per cent (Saskatchewan) to 6.5 per cent (Quebec), in Chemistry from 34.2 per cent (Quebec) to 11.8 per cent (B.C.) and in Physics from 32.1 per cent (Quebec) to 7.1 per cent (B.C.). The raw scores are

1)	British Columbia	50.0
2)	Ontario	48.0
3)	Alberta	47.0
4)	Manitoba	43.75
5)	New Brunswick	41.5
6-7)	Prince Edward Island	39.5
6-7)	Nova Scotia	39.5
8)	Saskatchewan	39.0
9)	Newfoundland	37.25
10)	Quebec	36.8

As in the international comparisons, we adjusted four years of schooling and retention rates (Appendix C).

After adjustment, the provincial scores become

1)	British Columbia	61.9
2)	Alberta	59.5
3-4)	Quebec	43.7
3-4)	Ontario	43.7
5)	Saskatchewan	43.5

6) Manitoba	43.4
7) Nova Scotia	36.8
8) Prince Edward Island	34.6
9) New Brunswick	30.8
10) Newfoundland	25.2
International mean	54.5

West to East correlation = $+ .84$ $p < .001$

The following points deserve attention:

- The adjustment moved Quebec sharply up (from the 10th to the 3-4th position).
- Except for British Columbia and Alberta, which compare very well with the best of the industrialized countries, all other provinces are far below the international mean. Indeed all but the two leading provinces are scoring poorer than the USA, whose weak performance has evoked so much justified criticism in recent years.

First International Assessment of Educational Progress

The Princeton-based Educational Testing Services (ETS) tested 13 year olds of nine systems in 1988 in mathematics and science. The mathematics test covered 62 items — 24 on numbers and operations, 6 on functions relations and algebraic expressions, 8 on geometry, 10 on measurement, 6 on data organization and interpretation and 8 on logic and problem solving. The percentage of correct answers were

1) Korea	75.9
2) Quebec	71.1
3) British Columbia	70.6
4) New Brunswick	67.1
5) Spain	65.4
6) Ontario	65.1
7) United Kingdom	64.4
8) Ireland	62.2
9) USA	56.2

Ontario's weak showing is noteworthy, as is that of the USA.

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The science test consisted of 54 items — 14 on the life sciences, 10 on physics, 8 on chemistry, 8 on the earth and space sciences and 14 on the nature of science. The results were

1) British Columbia	69.0
2) Korea	68.7
3) United Kingdom	63.8
4) Quebec	62.9
5) Ontario	62.6
6) Spain	61.7
7) New Brunswick	60.1
8) USA	56.4
9) Ireland	55.4

Here the interesting points are the strong performance of B.C. (outscored Korea) and the weak one of New Brunswick.

Second International Assessment of Educational Progress (1990-91)

Mathematics (Age 9)

Fourteen (14) systems participated at this age level, but the organizer of the study, the Educational Testing Service (ETS), judged that the results of four of them should be treated with reservations. The low participation of schools or students of these systems, or the exclusion of certain students renders the findings non-comparable with the main part of the study. These four systems were, at the Age 9 level, the province of Emilia-Romagna of Italy, Scotland, England and Portugal. We shall exclude these systems from our further discussion.

At this age, the test consisted of 61 items. 32 were on numbers and operations, 9 on measurement, 6 on geometry, 8 on data analysis, statistics and probability, and 6 on algebra and functions. The results of the retained systems are

1) Korea	74.8
2) Hungary	68.2
3) Taiwan	68.1
4) Soviet Union	65.9
5) Israel	64.4
6) Spain	61.9
7) Ireland	60.0
8) Canada	59.9
9) United States	58.4
10) Slovenia	55.8
International mean	63.7

The following points should be noted

- Soviet Union is represented by the Russian-speaking schools of 14 Republics (Uzbekistan was excluded).
- For Israel only Hebrew-speaking public schools were included.
- For Spain only Spanish-speaking schools were included. Valencian- and Basque-speaking schools and all schools in the Catalan autonomous community were excluded.
- In this age group Canada was represented by British Columbia, Ontario, Quebec, and the English-speaking schools of New-Brunswick only.

Notable results of Age 9 Mathematics are the strong showing of the Far-eastern countries of Korea and Taiwan, and of Hungary and the weak scores of Canada and the United States.

The detailed results of the participating Canadian systems are

Quebec	64.3
British Columbia	61.9
New Brunswick	59.8
Ontario	56.7
International mean	63.7

Note that only Quebec scores above the 10 country mean and Ontario's score is even lower than that of the United States.

Mathematics (Age 13)

At this age group 21 systems participated, but six of these are subject to severe reservations for reasons given above (China, England, Portugal, two systems of Brazil, and Mozambique). We also excluded one of the systems that was not subject to the reservations, but cannot be regarded as an industrialized country (Jordan). The test contained 75 items. 27 were on numbers and operations, 13 on measurement, 11 on geometry, 9 on data analysis, statistics and probability, and 15 on algebra and functions. The percentage of correct answers for the 14 industrialized countries with comprehensive populations are

1)	Korea	73.4
2)	Taiwan	72.7
3)	Switzerland	70.8

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4)	Soviet Union	70.2
5)	Hungary	68.4
6)	France	64.2
7)	Italy, Emilia-Romagna	64.0
8)	Israel	63.1
9)	<i>Canada</i>	62.0
10)	Scotland	60.6
11)	Ireland	60.5
12)	Slovenia	57.1
13)	Spain	55.4
14)	United States	55.3
	International mean	64.1

As with the Age 9 group, several points have to be noted:

- Switzerland includes only the German-French-, and Italian-speaking public schools in 15 cantons. Students in private and Romansch-speaking schools of the 15 cantons and all students of the remaining 11 cantons were excluded.
- Soviet Union includes only Russian speaking schools of 14 Republics Non-Russian speaking schools and all schools in Uzbekistan republic were excluded.
- Italy was represented by the province of Emilia-Romagna only.
- Israel included only Hebrew-speaking public schools Non-public and Arab-speaking schools were excluded.
- Canada included all provinces, except Prince Edward Island.
- Spain included all Spanish-speaking schools, except those in the Catalan autonomous community. Also Valencian- and Basque-speaking schools were excluded.

Once again, Korea and Taiwan are in first-second place. Among the European countries Switzerland, the Soviet Union and Hungary scored high. Canada is below the international mean of the 14 industrialized systems. The United States is in last place.

The scores of the nine participating Canadian provinces were

1)	Quebec	68.4
2)	British Columbia	66.2
3)	Alberta	64.0

4)	Saskatchewan	62.2
5)	Nova Scotia	59.7
6)	Newfoundland	58.9
7)	New Brunswick	58.7
8)	Manitoba	58.5
9)	Ontario	58.1
	International mean	64.1

West to East rank correlation = +0.37, p = not significant

There is a very substantial difference between the strongest and weakest Canadian province. Quebec's showing is impressive, Ontario's surprisingly weak. This test is the only one where the West to East tilt is not statistically significant.

Science (Age 9)

Regarding the exclusions and other caveats, the same comments apply here as in the Mathematics part of the Second International Assessment of Educational Progress. The only difference is that Mozambique did participate in the Mathematics part (though we excluded it from our listing, with other countries, as non-representative), but did not participate in the Science part. The test for this age group consisted of 58 questions. 23 dealt with the life sciences, 17 with the physical sciences, 10 with earth and space sciences and 8 with the nature of science. The percentage of correct answers were

Age 9

1)	Korea	67.9
2)	Taiwan	66.7
3)	United States	64.7
4)	<i>Canada</i>	62.8
5)	Hungary	62.5
6)	Spain	61.7
7)	Soviet Union	61.5
8)	Israel	61.2
9)	Slovenia	57.7
10)	Ireland	56.5
	International mean	62.3

18 International and Interprovincial Comparisons of

Noteworthy results

As in the case of mathematics, we observe a strong showing of Korea and Taiwan. At age 9, United States and Canada are ranking high and above the international mean.

The scores of the four participating Canadian provinces are

British Columbia	65.9
Quebec	62.8
Ontario	62.1
New Brunswick	61.6

Note that at age 9 there is relatively little difference in the Science achievement of the four participating Canadian provinces.

Science (Age 13)

The test of this age group contained 64 questions; 19 dealt with the life sciences, 25 with physical sciences, 9 with earth and space sciences, and 11 with the nature of science. The percentage of correct answers were

1)	Korea	77.5
2)	Taiwan	76.0
3)	Switzerland	73.7
4)	Hungary	73.4
5)	Soviet Union	71.3
6)	Slovenia	70.3
7)	Italy, Emilia-Romagna	69.9
8)	Israel	69.7
9)	<i>Canada</i>	68.8
10)	France	68.6
11)	Scotland	67.9
12)	Spain	67.5
13)	United States	67.0
14)	Ireland	63.3
	International mean	70.3

It is noteworthy that the first five countries on this list are identical with the first five on the age 13 Mathematics list. Canada is below the mean in both lists. The United States is close to the bottom.

The scores of the nine participating Canadian provinces were

1)	Alberta	74.1
2)	British Columbia	72.4
3)	Quebec	71.2
4)	Saskatchewan	69.9
5)	Nova Scotia	68.7
6)	Manitoba	68.4
7)	Ontario	66.7
8)	Newfoundland	66.1
9)	New Brunswick	65.4
	International mean	70.3

West to East rank correlation = $+ .716$ $p < .05$

It is gratifying to observe that Alberta scores higher than all but the two highest scoring foreign systems (Korea and Taiwan); however, only three Canadian provinces score above the international mean. Ontario, Newfoundland and New Brunswick place lower than the United States. There are disconcertingly big interprovincial differences. The West to East tilt is statistically significant.

5) *National Geographic Survey of Geographic Knowledge (1988-89)*

The National Geographic Society commissioned the Gallup Organization to conduct a survey of knowledge of geography in 10 countries. Part of this survey was the task of identifying 16 geographical concepts (specified countries or oceans) on a map.

For adults aged 18 and over the percentage correct were:

1)	Sweden	72.5
2)	West Germany	70.0
3)	Japan	60.6
4)	France	58.1
5)	Canada	57.5
6)	United States	53.8
7)	United Kingdom	53.1
8)	Italy	47.5
9-10)	Mexico	46.2
9-10)	USSR	46.2

Note that the sample of the USSR was restricted to the cities of Moscow and Kursk. Canada's score is mediocre and well below those of Sweden and West Germany.

20 International and Interprovincial Comparisons of

Gallup also reported the results of the subsample of the 18-24 year olds. These were:

1)	Sweden	74.4
2)	West Germany	70.0
3)	Japan	59.4
4-5-6)	Canada	58.1
4-5-6)	Italy	58.1
4-5-6)	USSR	58.1
7)	France	57.5
8)	United Kingdom	56.2
9)	Mexico	51.2
10)	USA	43.1

In this young age group, Sweden and West Germany still lead, while Canada's score is mediocre. The young citizens of the USSR are doing much better than the older ones, while just the opposite holds true for young Americans.

6) Southam Literacy Study (1987)

The Southam Company commissioned a study of Literacy in Canada in 1987. For all literates (marginal and fuller literates) the study found the following percentages:

1)	British Columbia	83
2)	Manitoba + Saskatchewan	81
3)	Alberta	79
4)	Ontario	76
5)	Maritimes	75
6)	Quebec	72
7)	Newfoundland	56

West to East correlation = $+0.93$ $p < .01$

For those surveyed persons who were born in Canada, the percentages were

1-2)	British Columbia	85
1-2)	Alberta	85
3)	Manitoba + Saskatchewan	83
4)	Ontario	80
5)	Maritimes	78
6)	Quebec	71
7)	Newfoundland	56

West to East correlation = $+0.96$ $p < .01$

When categorized according to the province where the surveyed persons received most of her/his elementary school education, the literacy rates were

1)	Manitoba	85.6
2-3)	British Columbia	82.8
2-3)	Alberta	82.8
4)	Saskatchewan	80.0
5)	Ontario	79.4
6)	Quebec	72.3
7)	Maritimes	69.4

West to East correlation = $+0.78$ $p < .05$

This calculation excludes those who had received their primary education outside Canada.

The Southam Literacy Study has been criticized for the quality and nature of its questions, its small sample size (16,540) and the low rate of willing and usable responses (14 per cent). It is noteworthy that, nevertheless, the Southam study's main findings agree surprisingly well with the much superior Statistics Canada Survey of Literacy Skills Used in Daily Activities (1990), which are the subject of Schweitzer (1992).

7) *Einsiedel Survey of Scientific Literacy (1990)*

Edna F. Einsiedel of the University of Calgary conducted in 1989 a survey of scientific literacy among 2000 adult Canadians. She constructed a Scientific Literacy Index with the following results:

Scientific Literacy Index

	Low	Moderate	High
West	28.5	45.5	26.0
Ontario	36.5	41.3	22.1
Quebec	55.0	34.9	10.1
Atlantic	46.0	39.2	14.8

Einsiedel found the differences significant at the 5 per cent level using the Chi square test. Inspection of the table shows that scientific literacy tends to decline from West to East.

SUMMING IT ALL UP

Internationally Canada's achievement is good or at least mediocre in the young age groups, but sinks way below average by the end of high school.

Interprovincially there is a rough declining trend going from West to East. The interprovincial differences are big. According to some observers this may be partly due to the Eastern provinces being the poorest ones, but it does not explain why Ontario, the richest province, is so mediocre. Schweitzer (1992) demonstrates that the relative prosperity of the provinces or the differences of spending on education per student do not fully explain the interprovincial differences in cognitive achievement. A successful exploration of the causes of these differences could yield extremely useful suggestions for the future improvement of the Canadian educational system.

Appendices

A Adjustment of the SIMS Population B scores for years of schooling and retentivity

We regressed the raw scores on years of schooling, mathematics retention rate, and dummy variables for branches of mathematics. The expected signs were positive for years of schooling, negative for the retention rates. The regression result was

	Coefficient	t-value	Variable
Y =	- 15.61	0.495	intercept + sets, relations functions dummy
	+ 7.16	2.59	years of schooling
	- 0.59	6.11	math retention rate
	- 11.81	3.16	dummy (number systems)
	- 3.28	0.89	dummy (algebra)
	- 18.92	5.06	dummy (geometry)
	- 16.73	4.47	dummy (functions and calculus)
	- 11.51	3.08	dummy (probability and statistics)
	- 2		
	R = 0.51		

The residuals of this equation can be regarded as the effect of the school systems net of years of schooling and retention rates. We used them as a proxy for the "quality" of mathematics education. Adding the weighted sum of the residuals of each system to the overall mean score of the participating countries we obtained the "adjusted" score of each system.

B Adjustment of the SISS population 3 scores for Years of Schooling and Retentivity. International Data

We regressed the raw scores on years of schooling, the respective science retention rates and dummy variables for branches of science. As in Appendix A, the expected signs were: positive for years of schooling, negative for retention rates. The regression result was:

	Coefficient	t-value	Variable
Y =	- 12.27	0.37	intercept + core test dummy
	+ 7.62	3.00	years of schooling
	- 0.23	2.23	retention rate
	- 26.75	5.73	dummy (biology)
	- 30.17	6.45	dummy (chemistry)
	- 29.29	6.39	dummy (physics)
	-2		
	R = 0.57		

C Adjustment of the SISS Population 3 Scores for Years of Schooling and Retentivity. Provincial Data

The regression result was

	Coefficient	t-value	Variable
Y =	+ 7.21	0.42	intercept + core test dummy
	+ 5.57	4.07	years of schooling
	- 0.19	3.91	retention rate
	- 28.17	10.58	dummy (biology)
	- 35.75	12.80	dummy (chemistry)
	- 37.02	12.40	dummy (physics)
	-2		
	R = 0.90		

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