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THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY REPEAT PROJECT (TIMSS–R)

ONTARIO REPORT: GRADE 8 STUDENTS

December 2000

THIRD INTERNATIONAL MATHEMATICS AND SCIENCE STUDY REPEAT PROJECT (TIMSS–R) ONTARIO REPORT: GRADE 8 STUDENTS[1]

Introduction

The Third International Mathematics and Science Study (TIMSS), a project of IEA, the International Association for the Evaluation of Educational Achievement, was designed to compare and contrast the teaching and learning of mathematics and science in elementary and secondary schools around the world. The first round of TIMSS data collection occurred in 1995 at Grades 3/4, 7/8 and the end of secondary school (Grade 12/OAC in Ontario). A repeat project (TIMSS–R) was conducted in 1999, and a third round of data collection is scheduled for 2003. For future projects TIMSS will stand for Trends In Mathematics and Science Study.

Participants

Thirty-eight countries took part in TIMSS–R, which focused on students in Grade 8. Twenty-six of these countries also participated in the original TIMSS, and they are indicated with an asterisk in the following list.

Australia*	Israel*	Philippines
Belgium (Flemish)*	Italy*	Romania*
Bulgaria*	Japan*	Russia*
Canada*	Jordan	Singapore*
Chile	Korea*	Slovak Republic*
Cyprus*	Latvia*	Slovenia*
Czech Republic*	Lithuania*	South Africa*
England*	Macedonia	Taiwan
Finland	Malaysia	Thailand*
Hong Kong*	Moldova	Tunisia
Hungary*	Morocco	Turkey
Indonesia	Netherlands*	United States*
Iran*	New Zealand*	

In May of 1999, a nationally representative sample of several thousand Canadian Grade 8 students took part in TIMSS–R. The Canadian sample included students and teachers from nine of the ten provinces; there was no participation from Prince Edward Island or the territories. For those countries and provinces that participated in both the original TIMSS and TIMSS–R, it was possible to compare the student achievement results of the student cohort that was in Grade 4 in 1995 and that was in Grade 8 in 1999. Five provinces drew large enough school and student samples (over-sampled) to generate representative, generalizable provincial statistics: British Columbia, Alberta, Ontario, Quebec and Newfoundland. In Ontario, 4,054 students from 112 English- and 74 French-language schools participated in the study.

[1] The information in this report is excerpted/adapted, with permission, from *TIMSS-Canada Report Volume 5: New Findings for a New Century* (Robitaille and Taylor, December 2000).

Data Sources

TIMSS involved student testing, as well as student, teacher and school questionnaires to collect contextual information about instruction and learning. All of the students wrote a 90-minute test in mathematics and science and completed a student questionnaire that gathered information about their attitudes toward math and science, classroom activities, home background and out-of-school activities. The mathematics and science teachers of sampled students were asked about their teaching emphasis, instructional practices, textbook usage, professional training and education, as well as their views on math and science. School principals responded to questions about school staffing and resources, math and science course offerings and teacher support.

Reporting Scales

In the Grade 8 reports (Canada and Ontario) for the original TIMSS study, results were reported in terms of percentage correct. In the case of TIMSS–R, a three-parameter IRT (Item-Response Theory) model was used to calculate scale scores. In order to facilitate comparisons of change between the two studies, the 1995 results were re-calculated using IRT methodology. Readers of the reports of both studies may, therefore, notice some differences between the numbers reported in the earlier report and the present one. Such differences do not, however, affect the overall results to any significant degree.

In the international report of TIMSS–R, issued by the International Study Center at Boston College, achievement results are reported on a scale with a mean of 500 and a standard deviation of 100. This scale tends to magnify what may in fact be small differences and might lead one to conclude that differences are larger than they really are. For that reason, a linear transformation of the results was conducted so that scores are reported here with a mean of 50 and a standard deviation of 10. This transformation does not affect the relative performance of the countries or the significance of inter-country or inter-provincial comparisons in any way. It simply makes the numbers used to report the results smaller and more comprehensible.

Test Structure

The TIMSS–R mathematics item pool dealt with five major content areas: fractions and number sense; geometry; algebra; measurement; and data representation, analysis, and probability. The tests included a majority of multiple-choice items together with short-answer and extended-response items. The structure of the 1999 mathematics test is summarized on the following page.

Structure of the TIMSS–R Mathematics Test (number and type of test items)

Content Area	Multiple-Choice	Short-Answer	Extended-Response	Total
Fractions and Number Sense	47	11	3	**61**
Geometry	21	1	0	**22**
Algebra	24	4	7	**35**
Data Representation, Analysis and Probability	19	1	1	**21**
Measurement	15	4	5	**24**
Total	**126**	**21**	**16**	**163**

The TIMSS–R science item pool dealt with six major content areas: earth science, life science, physics, chemistry, environmental and resource issues, and scientific inquiry. The tests included a majority of multiple-choice items together with short-answer and extended-response items. The structure of the 1999 science test is summarized below.

Structure of the TIMSS–R Science Test (number and type of test items)

Content Area	Multiple-Choice	Short-Answer	Extended-Response	Total
Earth Science	17	4	1	**22**
Life Science	28	7	5	**40**
Physics	28	11	0	**39**
Chemistry	15	2	3	**20**
Environmental and Resource Issues	7	2	4	**13**
Scientific Inquiry	9	2	1	**12**
Total	**104**	**28**	**14**	**146**

Approximately 50% of the original TIMSS items had never been released. Consequently, these items were also used in the 1999 study, along with new items that were developed to replace the 1995 items that had been made public. The new items were written so as to be parallel in form and content to the released ones, and all such items were piloted and revised or replaced as warranted. Samples of the TIMSS-R test items, together with relevant statistics and comments about student performance, are found in Appendix A of this report.

Curriculum Match

Comparing the TIMSS–R test items with provincial curriculum, Ontario Grade 8 students should have been taught the content required by the mathematics items except for formal deductive demonstrations of geometric relationships; sine, cosine and tangent in right-angle triangles; scales applied to maps and models; and solving simultaneous equations in two variables. This means that about 93% of the TIMSS–R content was covered by *The Ontario Curriculum*. With respect to science, Ontario Grade 8 students should have been taught the material required by approximately 60% of the TIMSS–R test items; the content related to the remaining items is presented to students in subsequent grades/years.

Information on the implemented curriculum, for both the Canadian and the international levels, is presented in Appendix B.

The above information relates specifically to the extent to which the TIMSS–R test items match *The Ontario Curriculum*; however, it should be noted that *The Ontario Curriculum* covers more content than is reflected in the TIMSS–R test.

Mathematics and Science Achievement

The following charts present summaries of how the mathematics and science achievement of students in the five Canadian provinces, as well as those in other countries, compared to that of Canadian and Ontario students overall. The jurisdictions are divided into three groups: those whose overall mean score was significantly higher than the Canadian/Ontario mean, those whose overall mean score was essentially the same as the Canadian/Ontario mean and those whose overall mean score was significantly lower than the Canadian/Ontario mean. [The expression "significantly higher/lower," as used in this report, means that in 19 cases out of 20 (95% of the time), a difference of this size indicates a true difference and not one attributable to chance.] Countries are arranged alphabetically within each group to emphasize that differences between them may be too small to be considered important.

Appendix C provides total scores in mathematics and science for Canada, the provinces that over-sampled and the international overall scores, as well as the content area/subscale scores in mathematics and science for Canada and the provinces that over-sampled.

Mathematics Achievement of Countries and Provinces Compared to Canada[2]

Results Significantly Higher than Canada	Results the Same as Canada	Results Significantly Lower than Canada
Belgium (Flemish) 56 (0.3)	*Alberta* 53 (0.4)	Chile 39 (0.4)
Hong Kong 58 (0.4)	Australia 53 (0.5)	Cyprus 48 (0.2)
Japan 58 (0.2)	*British Columbia* 52 (0.6)	England 50 (0.4)
Korea 59 (0.2)	Bulgaria 51 (0.6)	Indonesia 40 (0.5)
Quebec 57 (0.5)	Czech Republic 52 (0.4)	Iran 42 (0.3)
Singapore 60 (0.6)	*Canada* 53 (0.3)	Israel 47 (0.4)
Taiwan 59 (0.4)	Finland 52 (0.3)	Italy 48 (0.4)
	Hungary 53 (0.4)	Jordan 43 (0.4)
	Malaysia 52 (0.4)	Latvia 51 (0.3)
	Netherlands 54 (0.7)	Lithuania 48 (0.4)
	Ontario (All) 52 (0.3)	Macedonia 45 (0.4)
	Ontario (Eng) 52 (0.3)	Moldova 47 (0.4)
	Russia 53 (0.6)	Morocco 34 (0.3)
	Slovak Republic 53 (0.4)	*Newfoundland* 50 (0.6)
	Slovenia 53 (0.3)	New Zealand 49 (0.5)
		Ontario (Fr) 51 (0.3)
		Philippines 35 (0.6)
		Romania 47 (0.6)
		South Africa 28 (0.7)
		Thailand 47 (0.5)
		Tunisia 45 (0.2)
		Turkey 43 (0.4)
		United States 50 (0.4)

[2] Mathematics achievement scale scores are provided for each jurisdiction; standard error statistics are provided in parentheses. The 95% confidence interval for each jurisdiction can be calculated by adding and subtracting two standard errors to and from each reported mean score. This means that we can be 95% sure (19 times out of 20) that the true mean for a given jurisdiction lies within the confidence interval. If the confidence intervals of two jurisdictions overlap, we can conclude there is no statistically significant difference in their achievement scores.

The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly grouped. However, the groupings above are accurate and reflect the international scale scores with means of 500.

Mathematics Achievement of Countries and Provinces Compared to Ontario[3]

Results Significantly Higher than Ontario	Results the Same as Ontario	Results Significantly Lower than Ontario
Belgium (Flemish) 56 (0.3)	*Alberta* 53 (0.4)	Chile 39 (0.4)
Hong Kong 58 (0.4)	Australia 53 (0.5)	Cyprus 48 (0.2)
Hungary 53 (0.4)	*British Columbia* 52 (0.6)	England 50 (0.4)
Japan 58 (0.2)	Bulgaria 51 (0.6)	Indonesia 40 (0.5)
Korea 59 (0.2)	*Canada* 53 (0.3)	Iran 42 (0.3)
Netherlands 54 (0.7)	Czech Republic 52 (0.4)	Israel 47 (0.4)
Quebec 57 (0.5)	Finland 52 (0.3)	Italy 48 (0.4)
Singapore 60 (0.6)	Latvia 51 (0.3)	Jordan 43 (0.4)
Slovak Republic 53 (0.4)	Malaysia 52 (0.4)	Lithuania 48 (0.4)
Taiwan 59 (0.4)	*Newfoundland* 50 (0.6)	Macedonia 45 (0.4)
	Ontario (All) 52 (0.3)	Moldova 47 (0.4)
	Ontario (Eng) 52 (0.3)	Morocco 34 (0.3)
	Ontario (Fr) 51 (0.3)	New Zealand 49 (0.5)
	Slovenia 53 (0.3)	Philippines 35 (0.6)
	Russia 53 (0.6)	Romania 47 (0.6)
		South Africa 28 (0.7)
		Thailand 47 (0.5)
		Tunisia 45 (0.2)
		United States 50 (0.4)

[3] Mathematics achievement scale scores are provided for each jurisdiction; standard error statistics are provided in parentheses. The 95% confidence interval for each jurisdiction can be calculated by adding and subtracting two standard errors to and from each reported mean score. This means that we can be 95% sure (19 times out of 20) that the true mean for a given jurisdiction lies within the confidence interval. If the confidence intervals of two jurisdictions overlap, we can conclude there is no statistically significant difference in their achievement scores.

The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly grouped. However, the groupings above are accurate and reflect the international scale scores with means of 500.

Achievement on Mathematics Content Areas

The following chart provides a summary of Canadian, provincial and international student achievement on the five mathematics content areas.

Mathematics Achievement by Content Areas[4]

	Fractions and Number Sense	Measurement	Data Representation, Analysis and Probability	Geometry	Algebra
International	49 (0.1)	49 (0.1)	49 (0.1)	49 (0.1)	49 (0.1)
Canada	53 (0.3)↑	52 (0.2)↑	52 (0.5)↑	51 (0.5)↑	53 (0.2)↑
Alberta	53 (0.3)↑	52 (0.3)↑	53 (0.3)↑	49 (0.3)=	53 (0.3)↑
British Columbia	53 (0.5)↑	52 (0.5)↑	51 (0.5)↑	49 (0.4)=	52 (0.5)↑
Newfoundland	51 (0.5)↑	50 (0.5)=	50 (0.5)=	50 (0.5)=	51 (0.6)↑
Ontario (All)	52 (0.3)↑	51 (0.3)↑	51 (0.2)↑	50 (0.2)↑	52 (0.2)↑
Ontario (Eng)	52 (0.3)↑	51 (0.3)↑	51 (0.3)↑	50 (0.2)↑	52 (0.3) ↑
Ontario (Fr)	52 (0.2)↑	51 (0.3)↑	50 (0.3)↑	50 (0.3)↑	51 (0.3)↑
Quebec	56 (0.4) ↑	55 (0.4)↑	55 (0.4)↑	54 (0.4)↑	55 (0.4)↑

↑ Significantly higher than the international average

= Essentially the same as the international average

[4] The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly categorized as significantly higher than or essentially the same as the international average. The categorization of provincial achievement scores is accurate and reflects the international scale scores with means of 500.

Science Achievement of Countries and Provinces Compared to Canada[5]

Results Significantly Higher than Canada	Results the Same as Canada	Results Significantly Lower than Canada
Alberta 56 (0.5)	Australia 54 (0.4)	Chile 42 (0.4)
Hungary 55 (0.4)	Belgium (Flemish*)* 54 (0.3)	Cyprus 46 (0.2)
Japan 55 (0.2)	*British Columbia* 54 (0.5)	Indonesia 44 (0.5)
Korea 55 (0.3)	Bulgaria 52 (0.5)	Iran 45 (0.4)
Singapore 57 (0.8)	*Canada* 53 (0.2)	Israel 47 (0.5)
Taiwan 57 (0.4)	Czech Republic 54 (0.4)	Italy 49 (0.4)
	England 54 (0.5)	Jordan 45 (0.4)
	Finland 54 (0.4)	Latvia 50 (0.5)
	Hong Kong 53 (0.4)	Lithuania 49 (0.4)
	Netherlands 55 (0.7)	Macedonia 46 (0.5)
	Ontario (All) 52 (0.3)	Malaysia 49 (0.4)
	Ontario (Eng) 52 (0.3)	Moldova 46 (0.4)
	Quebec 54 (0.5)	Morocco 32 (0.4)
	Russia 53 (0.6)	*Newfoundland 51 (0.6)*
	Slovak Republic 54 (0.3)	New Zealand 51 (0.5)
	Slovenia 53 (0.3)	*Ontario (Fr) 48 (0.4)*
		Philippines 35 (0.8)
		Romania 47 (0.6)
		South Africa 24 (0.8)
		Thailand 48 (0.4)
		Tunisia 43 (0.3)
		Turkey 43 (0.4)
		United States 52 (0.5)

[5] Science achievement scale scores are provided for each jurisdiction; standard error statistics are provided in parentheses. The 95% confidence interval for each jurisdiction can be calculated by adding and subtracting two standard errors to and from each reported mean score. This means that we can be 95% sure (19 times out of 20) that the true mean for a given jurisdiction lies within the confidence interval. If the confidence intervals of two jurisdictions overlap, we can conclude there is no statistically significant difference in their achievement scores.

The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly grouped. However, the groupings above are accurate and reflect the international scale scores with means of 500.

Science Achievement of Countries and Provinces Compared to Ontario[6]

Results Significantly Higher than Ontario	Results the Same as Ontario	Results Significantly Lower than Ontario
Alberta 56 (0.5)	Bulgaria 52 (0.5)	Chile 42 (0.4)
Australia 54 (0.4)	*Canada* 53 (0.2)	Cyprus 46 (0.2)
Belgium (Flemish) 54 (0.3)	Hong Kong 53 (0.4)	Indonesia 44 (0.5)
British Columbia 54 (0.5)	Latvia 50 (0.5)	Iran 45 (0.4)
Czech Republic 54 (0.4)	*Newfoundland 51 (0.6)*	Israel 47 (0.5)
England 54 (0.5)	New Zealand 51 (0.5)	Italy 49 (0.4)
Finland 54 (0.4)	*Ontario (All)* 52 (0.3)	Jordan 45 (0.4)
Hungary 55 (0.4)	*Ontario (Eng) 52 (0.3)*	Lithuania 49 (0.4)
Japan 55 (0.2)	Russia 53 (0.6)	Macedonia 46 (0.5)
Korea 55 (0.3)	United States 52 (0.5)	Malaysia 49 (0.4)
Netherlands 55 (0.7)		Moldova 46 (0.4)
Quebec 54 (0.5)		Morocco 32 (0.4)
Singapore 57 (0.8)		*Ontario (Fr) 48 (0.4)*
Slovak Republic 54 (0.4)		Philippines 35 (0.8)
Taiwan 57 (0.4)		Romania 47 (0.6)
Slovenia 53 (0.3)		South Africa 24 (0.8)
		Thailand 48 (0.4)
		Tunisia 43 (0.3)
		Turkey 43 (0.4)

[6] Science achievement scale scores are provided for each jurisdiction; standard error statistics are provided in parentheses. The 95% confidence interval for each jurisdiction can be calculated by adding and subtracting two standard errors to and from each reported mean score. This means that we can be 95% sure (19 times out of 20) that the true mean for a given jurisdiction lies within the confidence interval. If the confidence intervals of two jurisdictions overlap, we can conclude there is no statistically significant difference in their achievement scores.

The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly grouped. However, the groupings above are accurate and reflect the international scale scores with means of 500.

Achievement on Science Content Areas

The following chart provides a summary of Canadian, provincial and international student achievement on the six science content areas.

Science Achievement by Content Areas[7]

	Earth Science	Life Science	Physics	Chemistry	Environmental and Resource Issues	Scientific Inquiry
International	49 (0.1)	49 (0.1)	49 (0.1)	49 (0.1)	49 (0.1)	49 (0.1)
Canada	52 (0.4) ↑	52 (0.4) ↑	52 (0.4) ↑	52 (0.5) ↑	52 (0.4) ↑	53 (0.5) ↑
Alberta	55 (0.4) ↑	55 (0.4) ↑	54 (0.4) ↑	54 (0.4) ↑	55 (0.3) ↑	55 (0.2) ↑
British Columbia	52 (0.4) ↑	53 (0.4) ↑	53 (0.4) ↑	53 (0.4) ↑	52 (0.4) ↑	54 (0.3) ↑
Newfoundland	51 (0.4) ↑	51 (0.5) ↑	50 (0.4) =	50 (0.4) ↑	51 (0.5) ↑	53 (0.4) ↑
Ontario (All)	50 (0.2) ↑	52 (0.3) ↑	51 (0.2) ↑	50 (0.2) ↑	51 (0.2) ↑	53 (0.2) ↑
Ontario (Eng)	50 (0.2) ↑	52 (0.3) ↑	51 (0.2) ↑	50 (0.3) ↑	51 (0.2) ↑	54 (0.2) ↑
Ontario (Fr)	49 (0.3) =	48 (0.3) =	48 (0.3) =	47 (0.3) ↓	47 (0.3) ↓	50 (0.2) ↑
Quebec	54 (0.4) ↑	51 (0.4) ↑	53 (0.4) ↑	54 (0.3) ↑	53 (0.4) ↑	53 (0.3) ↑

↑ Significantly higher than the international average

= Essentially the same as the international average

↓ Significantly lower than the international average

[7] The achievement scale scores and standard error statistics in the above chart are rounded figures; consequently, a few jurisdictions may appear to be incorrectly categorized as significantly higher than or essentially the same as the international average. The categorization of provincial achievement scores is accurate and reflects the international scale scores with means of 500.

Summary of Achievement Results

Canada:

- Canadian Grade 8 students performed relatively well in mathematics and science. Only six countries had achievement results that were significantly higher than Canada's in mathematics and only five in science. (The countries whose students had significantly higher scores than Canadian students, in both mathematics and science, were Japan, Korea, Singapore and Taiwan.)
- Canadian Grade 8 students had achievement scores that were significantly higher than the international average in all of the content areas of mathematics and science.
- In mathematics, there was no significant difference in the achievement scores of Canadian boys and girls. (This was the same result as in 1995.) The same trend was evident for all of the provinces that over-sampled (including Ontario) and almost all of the participating countries, with the exception of Czech Republic, Iran, Israel and Tunisia.
- In science, there was a significant difference between the performance of boys and girls (in favour of boys) in Canada. (There was no gender difference in 1995.) Among the provinces that over-sampled, Ontario overall (and Ontario English) and Alberta showed a significant difference in favour of boys. Similar gender differences were found in many other countries such as the Czech Republic, England, Hungary, Iran, Korea, Lithuania, Netherlands, Russia, Slovak Republic, Taiwan, Tunisia and the United States.
- Of the 26 countries that participated in both the original TIMSS (1995) and TIMSS–R (1999), Canada was one of only three countries in mathematics and one of only four countries in science that showed statistically significant score gains between the two studies.

Ontario:

- In both mathematics and science, Ontario Grade 8 student achievement was the same as Canada overall. (In 1995, Ontario Grade 8 students scored lower than Canada as a whole in both mathematics and science.)
- Among the five provinces that over-sampled, only Quebec Grade 8 students achieved higher scores than Ontario students in mathematics; Alberta, British Columbia and Quebec students scored higher than Ontario students in science.
- In mathematics, Ontario Grade 8 student achievement scores (Ontario English and Ontario French) were significantly higher than the international average in all five content areas: fractions and number sense, measurement, data representation analysis and probability, geometry and algebra. (In 1995, Ontario Grade 8 students performed at about the international average overall but scored lower than the international average in geometry, algebra and measurement.)
- In science, Ontario Grade 8 student achievement scores (Ontario overall and Ontario English) were significantly higher than the international average in all six content areas: earth science, life science, physics, chemistry, environmental and resource issues and scientific inquiry. Ontario French students scored higher than the international average in scientific inquiry; the same as the international average in earth science, life science and physics; and lower than the international average in chemistry and environmental and resource issues. (In 1995, Ontario

Grade 8 students performed at about the international average overall but scored lower than the international average in earth science and chemistry.)

- In mathematics, there was no significant difference in the achievement scores of Ontario Grade 8 boys and girls.
- In science, there was a significant difference between the performance of Grade 8 boys and girls (in favour of boys) in Ontario overall and Ontario English overall. Boys' achievement was higher than that of girls in the following content areas: earth science (English and French), physics (English), chemistry (English) and environmental and resource issues (English and French).
- In both mathematics and science overall, the achievement of Ontario Grade 8 students overall improved by a statistically significant margin between 1995 (TIMSS) and 1999 (TIMSS–R). Apart from science in Quebec, no significant changes were found in the other four provinces that over-sampled.

- Ontario Grade 8 students held relatively positive attitudes toward mathematics and science as compared with their counterparts across Canada and internationally. The following two charts illustrate this finding.

Students' Attitudes toward Mathematics (percentage agreement)

	Canada	Int'l	AB	BC	NF	ON	QC
I enjoy learning mathematics.	63	66	67	64	72	75	47
Mathematics is boring. (reverse scale)	42	37	47	52	42	37	38
Mathematics is an easy subject.	47	40	47	45	53	48	45
Mathematics is important to everyone's life.	94	91	92	92	96	96	95
I would like a job that involved using mathematics.	48	51	42	43	46	56	44

Students' Attitudes toward Science (percentage agreement)

	Canada	Int'l	AB	BC	NF	ON	QC
I enjoy learning science.	67	76	74	78	70	73	55
Science is boring. (reverse scale)	39	30	40	37	39	36	40
Science is an easy subject.	47	49	53	53	45	41	48
Science is important to everyone's life.	77	81	77	81	86	82	67
I would like a job that involved using science.	45	53	48	47	49	48	37

Appendix A

Sample Test Items

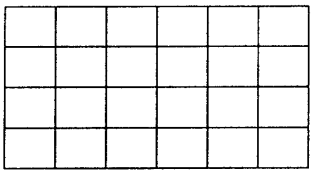
Looking at sample items and examining the item statistics is perhaps the best way to get a good sense of what sort of challenge Canadian students were asked to face on the TIMSS–R test. In the following two sections one sample item from each of the content areas is presented along with some summary statistics and a brief discussion.

Sample Mathematics Items

Fractions and Number Sense

An example of a free-response item in this area on which Canadian students did relatively well, compared to students elsewhere, is shown below. It involves the concept of a fraction as part of a whole.

N19. Shade in $\frac{3}{8}$ of the unit squares in the grid.



	Percentage Correct
Canada	68
International	49
Alberta	62
British Columbia	62
Newfoundland	63
Ontario	63
Quebec	88

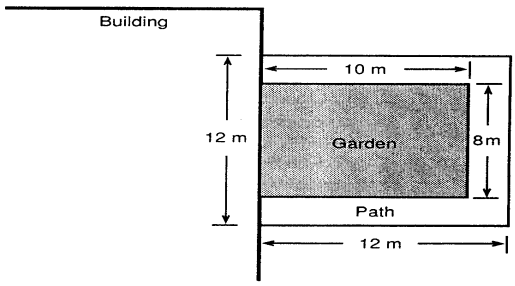
Canadian students did quite well on this item relative to the international average. Four of the provinces had similar results, between 62 and 63 %. Students in Quebec did particularly well on this item. This was the highest score obtained by students from any jurisdiction in the study.

The most common error students made was to shade in only three squares, which was the value of the numerator. Students providing this answer did not take into account there were a total of 24 rather than eight squares in the diagram. Only 10% in Canada made this mistake, but it was much more common in some other countries.

Measurement

Item J10, shown below, involves finding the area of a rectangle with an excluded region inside. The asterisk in the table indicates the correct response.

J10. A rectangular garden that is next to a building has a path around the other three sides, as shown.



What is the area of the path?

A. 144 m^2

B. 64 m^2

C. 44 m^2

D. 16 m^2

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	24	22	18	24	28	31	19
B.*	51	42	48	44	35	41	72
C.	20	24	29	24	26	22	6
D.	5	10	5	8	10	5	3
Other	1	3	1	1	0	1	0

* indicates the correct response

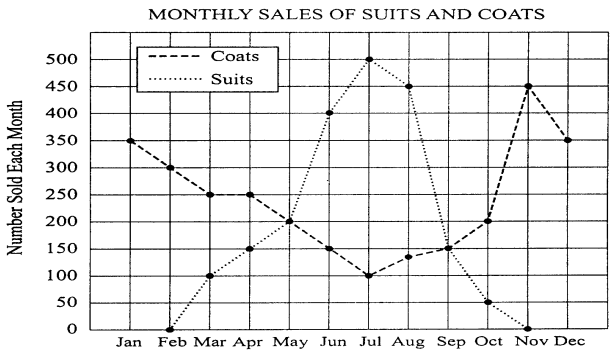
This item proved difficult for many students. For example, only 51% of Canadian students chose the correct answer while internationally, the correct response rate was only 42%. Almost one-quarter of the students in Canada and 22% internationally selected Option A, which was the area of the larger rectangle. Students selecting this option did not exclude the garden in calculating the area of the pathway. Another popular response was Option C, selected by 20% or more of the students in Canada and internationally. These students likely made an error in subtracting the area of the garden from the area of the larger rectangle.

Results on this item from among the provinces ranged from a low percentage correct of 35 to a high of 72. Only four countries—Taiwan, Japan, Hong Kong and Singapore—scored higher on this item than students in Quebec.

Data Representation and Analysis

Students in Canada did relatively well, compared to the international average, on Item B7, which is shown below. It involved reading information from a graph and then interpreting it.

B7. This graph shows the number of suits and coats sold each month.



According to the information in the graph, during which two-month period does the greatest increase in coat sales occur?

A. December - January

B. May - June

C. June - July

D. October - November

Percentage of Students

Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	7	17	5	8	11	9	3
B.	7	6	8	7	10	7	7
C.	10	16	9	13	12	12	7
D.*	75	60	78	73	67	72	82
Other	0	2	0	0	0	0	0

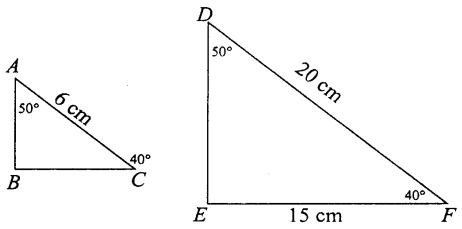
* indicates the correct response

Three-quarters of the students in Canada answered this item correctly. This was 15 percentage points higher than the international average of 60. Results from all the provinces were higher than the international mean with percents correct ranging from 67 to 82.

Geometry

The geometry item shown next was poorly done in most countries. It involved finding the length of a corresponding side of two similar triangles.

P10. The figure represents two similar triangles. The triangles are not drawn to scale.



In the actual triangle *ABC*, what is the length of side *BC*?

A 3.5 cm

B. 4.5 cm

C. 5 cm

D. 5.5 cm

E. 8 cm

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	23	22	32	24	33	25	17
B.*	35	37	31	39	34	34	41
C.	25	23	22	20	27	24	25
D.	9	8	9	11	3	11	7
E.	6	6	7	4	3	5	4
Other	2	4	0	2	1	2	5

* indicates the correct response

Only about one-third of Canadian students answered this question correctly, slightly below the international average of 37 percent. In only two countries, Japan and Korea, did more than two-thirds of the students select the correct answer. Results among the provinces ranged from 31% to 41%.

This question involved the use of a ratio to determine the value of a corresponding side in two similar triangles. It was a relatively straightforward item, given that the positions of corresponding sides and angles in both triangles were oriented in the same direction.

These results indicate that most students do not understand the relationship between corresponding sides of similar triangles. It is likely as well that many are unable to solve a proportional equation.

Algebra

Item N13 shown below involves finding the value of an expression by substituting a number for a variable. It is a free-response question on which students in Canada did relatively well.

N13. If $x = 3$, what is the value of $\frac{5x+3}{4x-3}$?

Answer: _____

	Percentage Correct
Canada	67
International	53
Alberta	63
British Columbia	65
Newfoundland	74
Ontario	66
Quebec	74

This item was done well by students in Canada with a percentage correct of 67 compared to an international average of 53. Among the provinces, Newfoundland and Quebec attained the highest scores. Only four countries, Taiwan, Hong Kong, Hungary and Singapore attained a higher score.

Sample Science Items

Earth Science

An example of an item from the earth science content area is shown below. It is a free-response item concerning what is needed to support life on another planet.

J9. Diana and Mario were discussing what it might be like on other planets. Their science teacher gave them data about Earth and an imaginary planet Proto. The table shows these data.

	Earth	Proto
Distance from a star like the Sun	148 640 000 km	902 546 000 km
Atmospheric pressure at surface of planet	101 325 Pa	100 Pa
Atmospheric conditions • gas components	21% oxygen 0.03% carbon dioxide 78% nitrogen	5% oxygen 5% carbon dioxide 90% nitrogen
• ozone layer	yes	no
• cloud cover	yes	no

Write down one important reason why it would be difficult for humans to live on Proto if it existed. Explain your answer.

	Percentage Correct
Canada	82
International	66
Alberta	88
British Columbia	81
Newfoundland	80
Ontario	83
Quebec	74

The item was answered correctly by 82% of the students in Canada, a result considerably better than the international average of 66%. In fact, all of the provinces did better than the international average with results ranging from 74% in Quebec to 88% in Alberta. Among the countries, only the Slovak Republic, with a score of 89%, had a higher score than Alberta.

Of those who responded correctly in Canada, almost two-thirds explained that there would be insufficient oxygen to breathe. Most of the other correct responses stated that it would be too cold due to the distance from a star such as the sun. The most frequent error involved repeating the information in the stem and table with no explanation.

Life Science

The example shown next, Item P3, is a free-response question from the life science area. It relates to tree growth.

P3. Ethan hammered a nail into the trunk of a young tree. Explain why the nail was still at the same height from the ground twenty years later even though the tree had grown to a height of 22 metres.

	Percentage Correct
Canada	59
International	41
Alberta	69
British Columbia	61
Newfoundland	64
Ontario	57
Quebec	58

Canadian students did well on this item compared to students elsewhere. Their average score was almost twenty percentage points higher than the international average. Only two countries, Belgium (Flemish) and Finland, with 65% and 64% respectively had higher scores than Canada on this item.

All of the provinces scored higher than the international average with results ranging from 57% in Ontario to 69% in Alberta. Alberta's score was the highest from among all jurisdictions in the study while Newfoundland and British Columbia were second and fourth respectively.

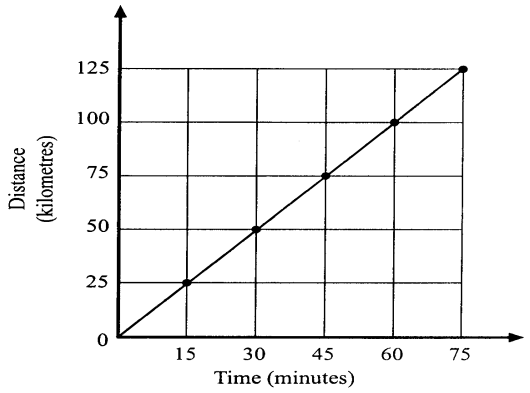
The most popular correct response noted that trees grow in height at the tips of stems or branches or that trunk growth increases in diameter. Some of the incorrect responses said that the trunk does not grow or that the nail stops or prevents growth. Only 8% of the students in Canada omitted this question; however, in some countries the rate of omission was very high. This was true, for example, in Chile, Macedonia, Morocco, the Philippines, Romania and South Africa.

The top scores attained by students in Finland and Canada may have been due, in part, to the abundance of trees and the importance of forestry to the economy of those two countries. It is possible that teachers in both places focused more on the growth of trees than did their counterparts in many other countries.

Physics

Item P1 from the physics subtest is shown next. It involves the interpretation of a graph and the calculation of speed as a ratio involving distance and time.

P1. The graph shows the progress made by a car traveling along a straight road.



What is the speed of the car?

A. 25 kilometres per hour

B. 50 kilometres per hour

C. 75 kilometres per hour

D. 100 kilometres per hour

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	9	12	12	11	20	11	6
B.	8	10	3	9	6	6	7
C.	14	22	13	14	20	17	8
D.*	68	54	72	65	52	66	78
Other	1	2	0	1	2	0	2

* indicates the correct response

More than two-thirds of Canadian students answered this question correctly, considerably higher than the international average of 54%. Among the provinces, results ranged from 52% in Newfoundland to 78% in Quebec. Quebec's result tied for second among countries, with only Hong Kong at 82% scoring higher.

In order to answer this item correctly, students needed to convert time from minutes to hours, and then calculate a ratio of distance over time. Since the graph is linear, students could use any location on the line to determine the ratio. It is likely that many chose a distance of 100 km and a time of 60 minutes, which easily converts to one hour.

Chemistry

Item F6, a Chemistry item, is shown next. It involves the role of paint in preventing the oxidation of iron.

F6. Paint applied to an iron surface prevents the iron from rusting. Which ONE of the following provides the best reason?

A. It prevents nitrogen from coming in contact with the iron.

B. It reacts chemically with the iron.

C. It prevents carbon dioxide from coming in contact with the iron.

D. It makes the surface of the iron smoother.

E. It prevents oxygen and moisture from coming in contact with the iron.

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	4	5	5	3	6	5	4
B.	8	9	7	7	10	10	5
C.	11	9	10	11	7	9	14
D.	4	8	3	2	4	6	3
E.*	72	67	75	75	71	70	73
Other	1	2	1	1	1	1	1

* indicates the correct response

Students in Canada attained a score of 72% on this item compared to the international average of 67%. The highest results internationally were obtained in Taiwan and Finland with scores of 91% and 83% respectively. Hungary, the Netherlands, Russia and Singapore each followed with 81%. Scores among the provinces ranged from 70% to 75%, all of which were above the international average.

The most frequent error, made by 11% of Canadian students, was selection of Option C. Students who selected this option thought, incorrectly, that carbon dioxide caused the oxidation or rusting of iron.

Environmental and Resource Issues

The item shown next, Item R6, is from the environmental and resource issues content area. It required students to recognize an effect of global warming.

R6. What is predicted to be a result of global warming?

A. Rising ocean level

B. More severe earthquakes

C. Larger volcanic eruptions

D. Thinning ozone layer

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.*	32	33	44	41	29	29	25
B.	8	7	5	5	8	7	11
C.	9	18	4	3	9	11	14
D.	51	40	45	51	52	52	49
Other	1	2	2	0	3	1	1

* indicates the correct response

This item was poorly done in most countries. For example, only about one-third of the students in Canada and internationally selected the correct answer. Japan, with 67%, had the highest score among all the countries. Hong Kong, Taiwan, Singapore, and Australia followed with 59%, 58%, 56%, and 52% respectively. In all other countries, less than half the students answered the question correctly. Results among provinces ranged from a low 25% to a high of 44%, reflecting a poor understanding of the effects of global warming.

The most popular incorrect response was Option D. More than half the students in Canada and 40% internationally thought that thinning of the ozone layer was an effect of global warming.

Scientific Inquiry and the Nature of Science

An example of an item involving observations and conclusions is shown next.

N4. Two open bottles, one filled with vinegar and the other with olive oil, were left on a window sill in the Sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation?

A. Vinegar evaporates faster than olive oil.

B. Olive oil evaporates faster than vinegar.

C. Both vinegar and olive oil evaporate.

D. Only liquids containing water evaporate.

E. Direct sunlight is needed for evaporation.

	Percentage of Students						
Response	Canada	Int'l	AB	BC	NF	ON	QC
A.	12	15	4	9	1	7	25
B.	2	4	1	2	3	3	1
C.*	64	48	83	68	80	64	47
D.	11	15	4	8	5	9	19
E.	12	17	8	12	12	16	8
Other	1	2	0	1	0	1	1

* indicates the correct response

Almost two-thirds of Canadian students answered this item correctly. This was considerably higher than the international average of 48%. Results by province ranged from highs of 83% and 80% in Alberta and Newfoundland respectively to a low of 47% in Quebec. This item was done exceptionally well in the two high scoring provinces, ranking them first and second among all of the jurisdictions.

In order to answer this item, students needed to understand which conclusion could be drawn from the experiment based only on the observation recorded. As a result, Option C was the correct answer since no other observations were recorded. Students who selected Option A may have used other knowledge to conclude that vinegar evaporates faster than olive oil. However, this conclusion could not be made on the basis of the observation provided in the experiment. Similarly, those who selected Option E could not conclude from this experiment that direct sunlight was needed for the evaporation to take place.

Appendix B

Implemented Mathematics and Science Curriculum

Participating mathematics and science teachers were asked to report whether or not the students in their TIMSS–R class had been taught each of a number of topics, either during the current school year or a previous one. The numbers in the cells of the following charts indicate the percentage of Canadian students (CA) and the percentage of students from all of the participating countries (INT'L) that had been exposed to each topic.

Percentage of Students Taught Selected Topics in Mathematics Before or During the Current School Year

	CA	INT'L		CA	INT'L
Fractions and Number Sense					
Whole numbers	99	98	Rounding — whole numbers and decimal fractions	100	95
Common fractions (concept and representation)	100	99	Estimation and computations	100	93
Common fractions (computations)	100	98	Number lines	100	92
Decimal fractions (concept and representation)	99	98	Percent — computation and problems	98	95
Decimal fractions (computations)	98	98	Negative numbers —computations	97	97
Relationships — common and decimal fractions	99	98	Square roots (of squares) and small integer exponents	96	83
Measurement					
Units of measurement: standard metric units	99	96	Perimeter and area of triangles, rectangles and circles	97	96
Reading measurement instruments	97	89	Perimeter and area of combined shapes	96	89
Estimates and accuracy of measurement	97	87	Volume of rectangular solids	68	87
Data Representation, Analysis, and Probability					
Representation and interpretation of data in graphs, charts and tables	91	75	Simple probabilities — understanding and calculations	72	43
Arithmetic mean	81	70			

Geometry	CA	INT'L		CA	INT'L
Cartesian coordinates of points in a plane	81	85	Congruence and similarity	84	72
Coordinates of points on a given straight line	84	84	Symmetry and transformations	78	63
Simple 2-dimensional geometry	94	95	Visualization of 3-dimensional shapes	63	57
Algebra					
Number patterns and relations	98	88	Solving simple equations	94	94
Simple algebraic expressions	98	94	Solving simple inequalities	50	66
Representing situations algebraically	92	90			

Fractions and Number Sense. All of the topics in this category were taught to the vast majority of students in most countries. In Canada, every subtopic under fractions and number sense topic was taught to between 96% and 100% of students. Similar proportions were found internationally with the exception of square roots of perfect squares. The international average on that topic was 83%, and in some countries—Japan, for example—the topic is apparently taught in very few classrooms.

Measurement. Most students in all countries were taught all of the topics in the measurement category. The topic with the lowest coverage rate was the volume of rectangular solids. Only 68% of students in Canada were taught this topic compared to 87% internationally. Among the countries in which more than 95% reported this level of coverage were Taiwan, the Czech Republic, Hong Kong, Hungary, Japan, Korea, and Singapore. On the other hand, fewer than 50% reported this level of coverage in Israel and Chile.

Data Representation, Analysis, and Probability. Over 70% of Canadian students were taught the three topics in this category, with elementary notions of probability being the one least likely to have been taught. There was considerable variation across countries with respect to coverage of elementary probability. In England over 90% of students have been taught about probability by this grade level. On the other hand, the topic is taught in very few classrooms in some other countries including Hong Kong and Japan.

Geometry. Coverage of these topics in Canada was very similar to the international average in most cases. On two of the topics—congruence and similarity, and symmetry and transformations—Canadian coverage rates were significantly higher than the international average. Fewer than half the students in New Zealand and the Netherlands were taught congruence and similarity in contrast to more than 95% in Japan, Korea, and Singapore. Among the countries in which more than 85% were taught symmetry and transformations were England and Japan, in contrast to Taiwan and Hong Kong where only 29% and 31% respectively were taught it. These results indicate that for the most part elementary notions of geometry are being taught in Canadian classrooms.

Algebra. Almost all Canadian students have been taught four of the five elementary aspects of algebra included in this category by the time they complete Grade 8. The only exception is the topic of simple inequalities for which the coverage rate in Canada is quite a bit lower than the international average. Some countries, including Japan and Korea, cover this topic more extensively at this level.

Percentage of Students Taught Selected Topics in Science Before or During the Current School Year

	CA	INT'L		CA	INT'L
Earth Science					
Earth's physical features (layers, landforms, bodies of water, rocks, soil)	91	77	Earth process and history (weather, physical cycle, plate tectonics, fossils)	86	71
Earth's atmosphere (layers, composition, etc.)	83	73	Earth in the solar system and the universe	80	71
Biology Life Science					
Human body — structure and function of organs and systems	54	84	Biology of plant and animal life (diversity, structure, life processes, life cycles)	70	87
Human bodily processes (metabolism, respiration and digestion)	49	83	Interactions of living things (biomes, ecosystems, and interdependence)	77	77
Human nutrition, health and disease	54	79	Reproduction, genetics, evolution and speciation	45	61
Physics					
Physical properties and changes of matter	97	91	Wave phenomena	35	52
Subatomic particles	44	71	Light	50	68
Energy types, sources and conversions	82	75	Electricity and magnetism	48	67
Heat and temperature	91	83	Forces and motion	56	65
Chemistry					
Classification of matter	80	90	Chemical reactivity and transformations	54	76
Structure of matter	63	84	Energy and chemical change	36	58

	CA	INT'L		CA	INT'L
Environmental and Resource Issues					
Pollution	92	78	Food supply and production, population and environmental effects	83	66
Conservation	90	76			
Scientific Inquiry and the Nature of Science					
Scientific method	99	88	Using scientific apparatus	99	87
Experimental design	97	84	Gathering, organizing and representing data	100	87
Scientific measurements	84	75	Describing and interpreting data	99	87

Earth Science. The vast majority of Canadian students have been taught the four major topics in earth science by the time they finish Grade 8. In every case, the coverage rate for Canadian students was higher than the international average. There was considerable variation across countries with respect to coverage of these topics. For example, only 6% in Japan and 17% in Hong Kong reported this level of coverage for the earth's physical features compared to more than 90% in the Czech Republic and Korea. This contrasted significantly with results for the earth in the solar system where 99% reported this level of coverage in Japan compared to only 15% in Hong Kong.

Life Sciences. Canadian coverage of the biology topics was considerably less than the international average in every case. For example, less than two-thirds of Canadian students were taught to the same level of coverage as their international counterparts in most topics. Only interactions of living things was given similar coverage in Canada as was the case internationally. England, the Netherlands, Singapore and the United States were among the countries with the highest levels of coverage while Canada was among the lowest.

Physics. Of the eight physics topics listed in the questionnaire, three had been covered by the vast majority of Canadian Grade 8 students: physical properties and changes of matter; energy types, sources, and conversions; and heat and temperature. In each of these cases, the Canadian coverage rate exceeded the international mean. In the other five areas, coverage in Canada was considerably below that of other countries. For example, only 44% were taught material dealing with subatomic particles. This compared to more than 95% in Taiwan, the Czech Republic and the Netherlands. A level of coverage similar to that of Canada's on this topic was reported in Hong Kong and Japan. Another topic that few students in Canada were taught was wave phenomena, sound and vibration. Only about one-third reported a high level of coverage in Canada, contrasting sharply with England, Japan, the Netherlands and Singapore, each with more than 80%.

Chemistry. The four chemistry topics were taught by lower proportions of teachers in Canada than internationally. For example, energy and chemical change was taught by only 36% in Canada compared to an international average of 58%. Among the countries in which this topic received much more coverage than in Canada were the Netherlands, Taiwan and England with 99%, 84% and 73% respectively.

Environmental and resource issues. The Canadian coverage rate for each of these topics was greater than the international average. This would seem to reflect the degree of interest that Canadians generally pay to environmental issues. It was interesting that pollution, with a coverage of 92% in Canada and 78% internationally received only 26% in Japan and 35% in Korea. The other two topics in this content area received very low coverage in Japan with only 7% in each. In contrast, the highest levels of coverage were in the Netherlands, ranging from 98% to 99% percent across the three topics.

Scientific inquiry and the nature of science. Virtually all Canadian students were taught these six topics, and Canadian coverage rates were greater than the international average in every case. There was very little variance among countries with more than 90% coverage in most cases**.**

Appendix C

Table 1. Total Scores for Mathematics and Science

	Mathematics		Science	
	Mean	Standard Error	Mean	Standard Error
Canada	53.1	0.25	53.3	0.21
International	48.7	0.07	48.8	0.07
Alberta	53.0	0.42	56.1	0.47
British Columbia	52.2	0.56	54.2	0.48
Newfoundland	50.4	0.61	51.2	0.56
Ontario All	51.7	0.30	51.8	0.31
Ontario — English	51.7	0.31	52.0	0.32
Ontario — French	51.1	0.33	47.6	0.40
Quebec	56.6	0.53	54.0	0.48

Table 2. Content Area/Subscale Scores (Mathematics)

	Fractions and Number Sense		Measurement		Geometry		Data Representation, Analysis and Probability		Algebra	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Canada	53.3	(0.25)	52.1	(0.24)	50.7	(0.47)	52.1	(0.45)	52.5	(0.24)
Alberta	53.4	(0.34)	52.3	(0.32)	49.3	(0.27)	52.6	(0.33)	52.6	(0.33)
British Columbia	52.9	(0.53)	51.6	(0.47)	49.2	(0.43)	51.4	(0.51)	51.7	(0.46)
Newfoundland	51.0	(0.52)	49.7	(0.49)	49.6	(0.47)	50.4	(0.54)	50.6	(0.56)
Ontario All	52.2	(0.25)	51.0	(0.25)	49.6	(0.22)	51.1	(0.24)	51.5	(0.24)
Ontario — English	52.2	(0.26)	51.0	(0.26)	49.6	(0.23)	51.1	(0.26)	51.5	(0.25)
Ontario — French	51.8	(0.24)	50.6	(0.25)	50.4	(0.28)	49.7	(0.26)	50.9	(0.27)
Quebec	56.2	(0.37)	55.2	(0.37)	54.4	(0.35)	55.2	(0.40)	55.1	(0.37)

Table 3. Content Area/Subscale Scores (Science)

	Earth Science		Life Science		Physics		Chemistry		Environmental Issues		Scientific Inquiry	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Canada	51.9	(0.37)	52.3	(0.38)	52.1	(0.38)	52.1	(0.54)	52.1	(0.35)	53.2	(0.51)
Alberta	55.1	(0.35)	54.5	(0.41)	53.6	(0.36)	53.6	(0.37)	54.5	(0.34)	55.1	(0.24)
British Columbia	52.1	(0.41)	52.9	(0.44)	53.4	(0.43)	53.3	(0.41)	51.8	(0.38)	53.6	(0.32)
Newfoundland	50.7	(0.43)	51.1	(0.46)	49.7	(0.41)	50.3	(0.43)	50.5	(0.49)	53.2	(0.35)
Ontario All	50.1	(0.23)	51.9	(0.27)	50.9	(0.24)	50.2	(0.24)	51.2	(0.24)	53.4	(0.19)
Ontario — English	50.1	(0.24)	52.1	(0.28)	51.0	(0.24)	50.4	(0.25)	51.4	(0.24)	53.6	(0.19)
Ontario — French	49.2	(0.29)	47.9	(0.33)	48.1	(0.33)	46.8	(0.26)	46.8	(0.26)	49.8	(0.21)
Quebec	53.8	(0.40)	51.2	(0.36)	53.2	(0.38)	53.5	(0.33)	52.9	(0.37)	52.7	(0.32)