Performance of BC Students in Mathematics and Science

Grades 7 and 8 Provincial, National, and International Assessments

June 2001

BRITISH COLUMBIA

Ministry of Education

Table of Contents

This document provides information on achievement of learning outcomes demonstrated by BC students in recent provincial, national, and international assessments of mathematics and science at grades 7 and 8.

Purpose of this Publication

This publication presents profiles of student achievement and attitudes that may provide direction for growth in the teaching and learning environments for students in grades 7 and 8 mathematics and science. The sections are as follows:

- a summary of results from multi-level assessments of mathematics and science;
- a summary of student responses to questions about their attitudes to and perceptions of mathematics and science;
- a summary of the pattern of strengths and weakness; and
- suggestions for instructional practice based on the above findings.

Assessment Measures Used

Three sources of information were used to prepare this publication. A brief description of each follows.

Foundations Skills Assessment (FSA)

Results from the numeracy component of the Foundation Skills Assessment FSA (2000) were used to compare the performance of Grade 7 students to provincial expectations. In this context numeracy is viewed as "the combination of mathematical problem solving and communication skills required by all persons to function successfully within our technological world. Numeracy is more than knowing about numbers and number operations." (British Columbia Association of Mathematics Teachers, 1998). Content areas assessed included the following: number, patterns and relations, shape and space, and statistics and probability.

School Achievement Indicators Project (SAIP)

The 1999 School Achievement Indicators Project (SAIP) was a national assessment designed to provide information on science achievement and attitudes of BC 13-year-olds. Areas examined were knowledge of science concepts, the nature of science, and the relationship of science to technology and societal issues. Results show the proportions of students at each of five levels of performance, ranging from very early stages of scientific literacy and awareness of the world around them to functional literacy in science acquired by a student who has completed a full range of specialized science courses at or near the end of secondary school.

Third International Mathematics and Science Study (TIMSS 99)

The Third International Mathematics and Science Study (TIMSS 99) was administered to a representative sample of BC students in Grade 8. Information was collected on achievement in and attitudes towards mathematics and science from students in 38 countries, including Canada. Information from this study enabled comparisons of performance at the provincial, national, and international levels. Results were reported by content category using average standard scores with a mean of 50 and standard deviation of 10.

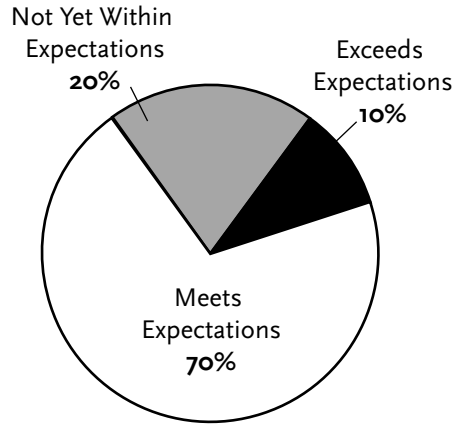
Summary of Assessment Results

Results for Mathematics

Student performance levels compared to provincial expectations are shown for numeracy at Grade 7. Average standard scores attained in several mathematics content areas are reported for Grade 8.

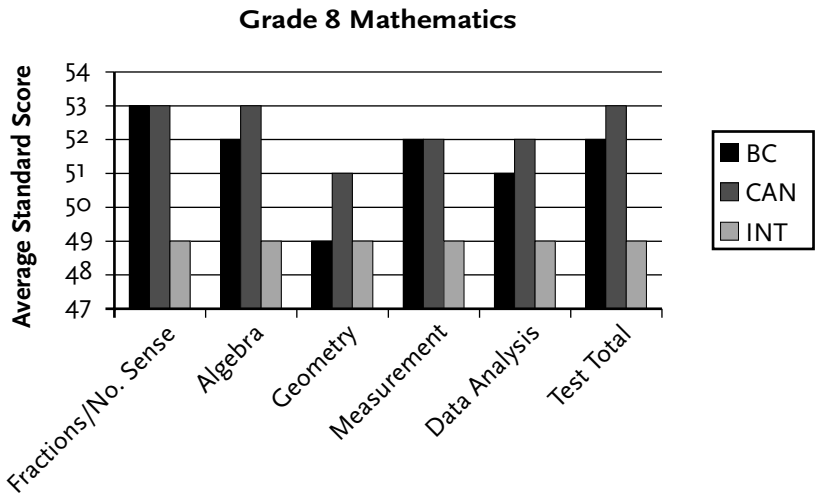
Grade 7 Numeracy (FSA 2000)

Numeracy Expectations - Grade 7



- Twenty percent of students were found to be not yet within expectations.
- Seventy percent met expectations.
- Ten percent exceeded expectations.
- Results for boys and girls were very similar. Proportions for each gender by expectation category were within one percentage point of each other.

Grade 8 Mathematics (TIMSS 99)



Note: Reported numbers are standard scores with a mean of 50 and standard deviation of 10.

Results by Content Area

- BC scored significantly higher than the international average on fractions and number sense, algebra, measurement, and data analysis.
- There was no significant difference between BC's score on geometry and the international average.
- BC results in geometry were considerably lower than those for Canada as a whole.

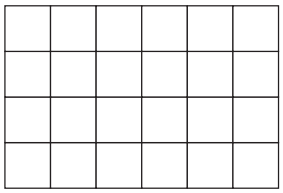
Total Test Results

- BC students scored statistically the same as Canada as a whole and higher than the international average on the total test.
- BC total test results were significantly higher than 21 countries, the same as 11, and significantly lower than 6.

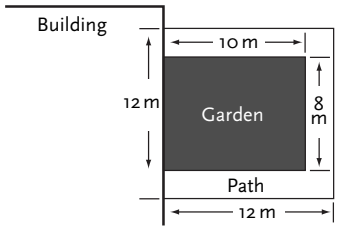
Other Achievement Results

- No significant change in levels of performance was found in BC between the 1995 and 1999 TIMSS assessments
- No significant differences were found between the achievement of boys and girls.
- Nine percent of BC students were in the top 10 percent internationally and more than 70 percent in the top half.

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



2. 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 m² C. 44 m²
B. 64 m² D. 16 m²

Sample Mathematics Items from TIMSS 99

1. A question done well

The question on the left involves the concept of fraction as part of a whole.

Sixty-two percent of BC students answered this open-ended question correctly (shading in 9 squares), compared to 68 percent in Canada as a whole and 49 percent internationally.

- The most common error was to shade in only 3 squares (the value of the numerator). This did not take into account that there were 24 squares in total and that 3/8 of the total was equivalent to 9 squares.

2. A question found difficult

This question involves finding the area of a rectangle with an excluded region.

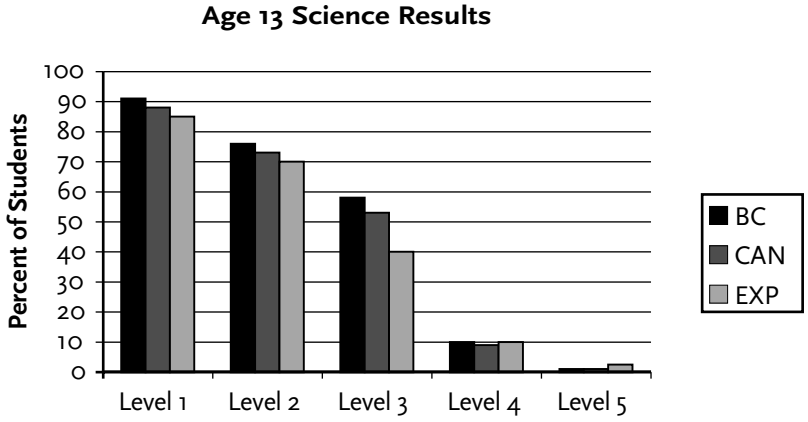
- Only 44 percent of BC students answered correctly (Option B). This compared to 51 percent in Canada as a whole and 42 percent internationally.
- Almost one-quarter selected option A, which was the area of the larger rectangle. These students did not exclude the garden area.
- The second-most common incorrect answer was option C. These students likely made an error in subtracting the larger area from the smaller.

Results for Science

The proportions of 13-year-old students in BC and Canada reaching levels 1 (fairly simple) to 5 (complex and sophisticated) in science are reported in relation to national expectations. Average standard scores attained in several science content areas are reported for Grade 8.

Age 13 Science (SAIP 1999)

Results for BC students



Note: A pan-Canadian panel of educators and non-educators expected that 70% of 13-year-old students should achieve at or above Level 2.

- More than 9 out of 10 (91 percent) performed at Level 1 or higher.
- About three-quarters (76 percent) were at Level 2 or higher.
- More than half (58 percent) achieved at Level 3 or higher.
- One tenth (10 percent) were at Level 4 or higher.
- One percent reached level 5.

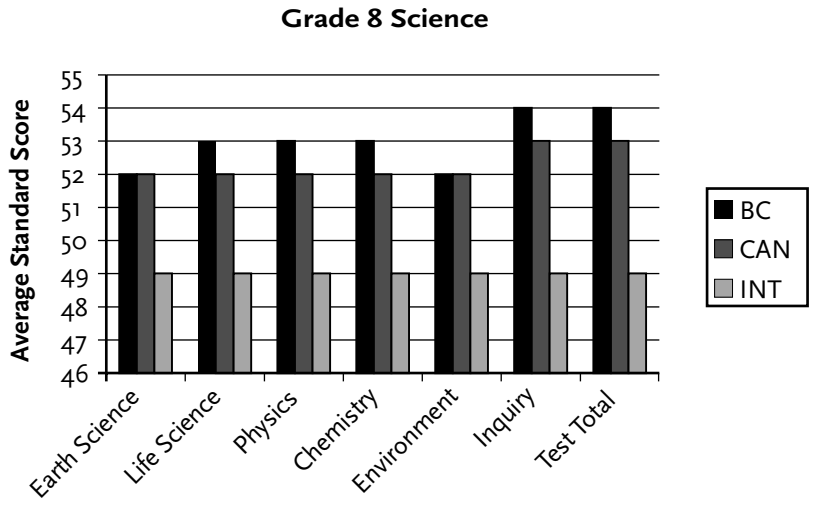
Comparisons with Canada

- Students in BC performed as well as or better than Canadians as a whole.
- Slightly more 13-year-olds in BC reached levels 1-4 than the Canadian average.
- BC students exceeded national expectations at levels 1, 2, and 3. They met them at level 4 but were lower at level 5.

BC Results over time

At levels 3 and 4, significant improvement was shown by BC students between 1996 and 1999.

Grade 8 Science (TIMSS 99)



Note: Reported numbers are standard scores with a mean of 50 and a standard deviation of 10.

Results by Content Area

BC scored significantly higher than the international average in all science content areas.

Total Science Test Results

- BC students scored statistically the same as Canada as a whole and significantly higher than the international average on the total test.
- BC total test results were significantly higher than 21 countries, the same as 12, and significantly lower than 5.

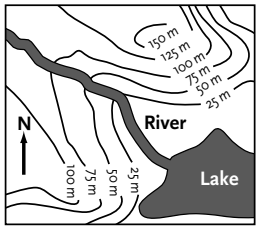
Other Achievement Results

- No significant change in performance level was found between the 1995 and 1999 TIMSS assessments.
- No significant differences were found between the achievement levels of boys and girls.
- Approximately 15 percent of BC students were in the top 10 percent internationally and more than 75 percent were in the top half.

1. 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.

2. On the diagram, hills and valleys are shown by means of contour lines. Each contour line indicates that all points on the line have the same elevation above sea level.



   In which direction does the river flow?
   A. Northeast
   B. Southeast
   C. Northwest
   D. Southwest
   E. It is not possible to tell from the map.

Sample Science Items from TIMSS 99

1. A question done well

The question to the left involves observations and conclusions.

In order to answer this question students needed to understand which conclusion could be drawn from the information given.

- More than two thirds (68%) of BC students answered correctly (Option C). This compared to 64 percent in Canada as a whole and only 48 percent internationally.
- The most common errors involved the selection of options where conclusions were drawn from prior knowledge or other information rather than the observations provided (e.g., Options D and E).

2. A question found difficult

This question about the earth's physical features was located under the Earth Science reporting category.

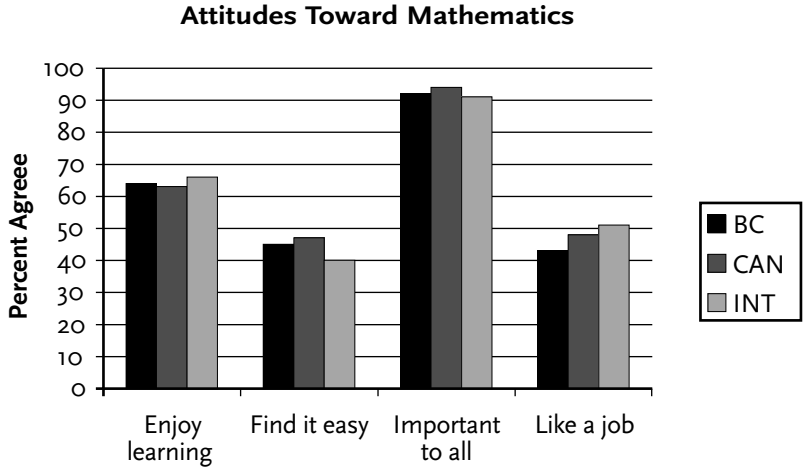
- Two key concepts were needed to arrive at the solution: (i) since the elevation went from higher to lower as the river approached the lake it was flowing into the lake, and (ii) the river went down and to the right of north, as shown in the compass legend, which meant it flowed in a southeast direction.
- Students in BC, Canada, and internationally found this question difficult, with only 50, 46 and 37 percent respectively answering correctly (Option B).
- Almost one-quarter of BC students selected the opposite direction to the correct one (Option C).

Student Attitudes

Students were asked a series of questions about their attitudes to and perceptions of mathematics and science in TIMSS 99 and similar questions about science in SAIP. Results from some of these questions are reported here.

Student Attitudes Towards Mathematics

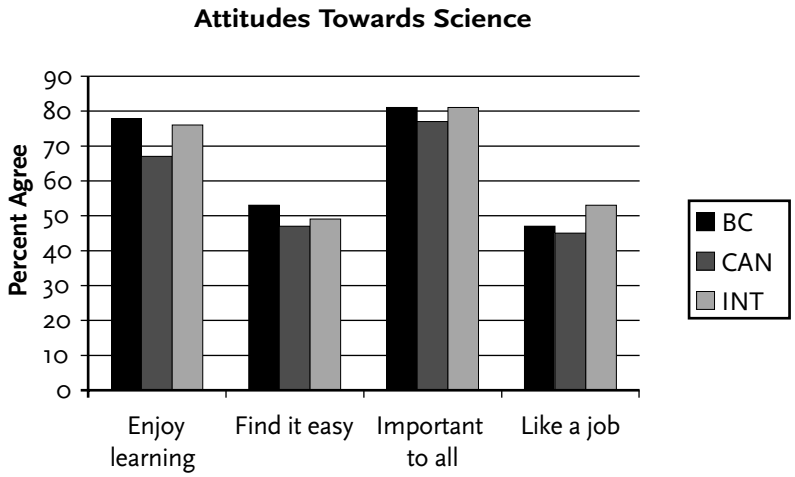
Results from TIMSS 99



- The vast majority of students agreed that mathematics is important to everyone's life (92 percent in BC, 94 percent in Canada as a whole and 91 percent internationally).
- The lowest ratings of agreement were with the statements *Mathematics is an easy subject* and *I would like a job that involved using mathematics.* Less than one half agreed with these statements.
- Generally, results from BC for all four questions were similar to both those for Canada as a whole and internationally.

Student Attitudes Towards Science

Results from TIMSS 99



- A large majority (between 77 and 81 percent) agreed that science is important to everyone's life. This is somewhat lower than for math.
- BC students were generally more positive than other Canadian and international students in their perceptions of enjoying science, its importance, and how easy it is.
- Only about one half of students in BC agreed that they would like a job involving science. This was slightly higher than their counterparts in Canada as a whole but slightly lower than the international mean.

Results from SAIP

- The vast majority (91%) of BC students agreed that science is an important school subject.
- Eight-five percent of students felt that many good jobs require the study of science.
- When faced with a difficult problem in science, 67 percent of students would likely keep trying until they solved the problem.

Patterns of Strength and Areas in Need of Greater Focus

Information in this section identifies areas of strength and weakness demonstrated by BC students. Results from the numeracy component of the FSA have been analyzed to identify these areas within each of its curriculum organizers: number, patterns and relations, shape and space, and statistics and probability. For Grade 8 mathematics and science, results for TIMSS 99 are provided for each of the content areas under which subtest results were reported.

Findings from Grade 7 Numeracy (FSA 2000)

Number

- Student results were good in the area of number and operations on questions involving single tasks and operations. In many cases, however, students had difficulty on questions with several steps. A large majority began multi-step questions correctly but made errors at subsequent steps leading to the solution.

Patterns and Relations

- Students had difficulty converting grams to kilograms. They also had difficulty finding the area of an irregular polygon by partitioning it and summing the areas of its parts.

Shape and Space

- Students did well in estimating height in metric units. They also did relatively well on a constructed response item that involved drawing different rectangular shapes with the same area on a grid (72 percent received either 3 or 4 out of 4). They did less well, however, on questions involving time intervals and the 24-hour clock. In addition, many were confused between the concepts of perimeter and area.

Statistics and Probability

- A large majority of students were able to read and interpret a bar graph. However, they were less successful on questions that involved combinations of objects and the probability of an event occurring with more than one possible favourable outcome. Almost half confused the mean with either the median or the mode.

Findings from Grade 8 Mathematics (TIMSS 99)

Fractions and Number Sense

- BC Students did well on questions that required recognition of a fraction as part of a whole, estimating and rounding whole numbers, ordering magnitudes of fractions and decimals, and basic operations with rational numbers. However, they had difficulty with two-step word problems involving numerical operations and applications of percent.

Algebra

- BC Students demonstrated strength on questions that involved finding the solution of simple equations, representing situations algebraically using formulas, and finding the relationship between numbers in ordered pairs. They did less well, however, when asked to find consecutive numbers given their sum and terms that contained a variable. They had considerable difficulty with inequalities and the relationships between ordered pairs in a table.

Measurement

- Most BC students were able to use correct units of measure for length, area, volume, and mass. They were also able to estimate length correctly and successfully answer single-step questions dealing with perimeter and area. However, few were able to find the area of a figure with an excluded region and many confused concepts of perimeter and area when they were part of the same problem.

Geometry

- BC students experienced difficulty with many of the topics in geometry. For example, most could not find corresponding sides and angles of similar and congruent figures when the figures were not oriented in exactly the same direction. Students also demonstrated a weak understanding of angles formed by transversals and parallel lines, finding angles in polygons, and using transformations for tiling.

Data Representation

- Most BC students were able to read and interpret bar graphs and tables. They were also able to compare average scores and find simple probability. Students were less successful, however, in interpreting data in a frequency table.

Proportionality

- BC students did well on questions that involved finding an unknown in a proportional equation. They had difficulty, however, in finding average speed, given distance and time. They also had difficulty solving two-step problems involving proportions.

Findings from Grade 8 Science (TIMSS 99)

Life Science

- BC students did very well on most questions involving the human body. Topics for questions done well in this area included the location of a human organ, pulse/breathing rate after exercise, structure and function of organs and systems, interpretation of senses, and the function of red blood cells. Students also did well on the topics of inheritance of traits, means by which traits are transferred from one generation to the next, and the role of vitamins. However, many of the questions dealing with biology of plant, animal, and other life forms were not done well. These involved questions on the levels of organization in living things, physical characteristics of prey, role of bacteria in converting milk to yogurt, definition of tissue, and the impact of cold on mammals and lizards.

Earth Science

- BC students did very well on a number of questions dealing with the earth's physical features, earth processes and history, the earth's atmosphere, the earth in the solar system and the universe. Among the questions on which students did exceptionally well were the following: reading a temperature table, movement of the earth's plates (relative position over millions of years), layers of earth (which is the hottest), amount of oxygen at different locations in the earth's atmosphere, and why the moon shines. Several questions related to the earth's physical features, however, were not well done. Topics from this area on which fewer than half the students answered correctly were as follows: likely age of mountains based on shape, caves caused by erosion of types of stone, and reading and interpreting a contour map. They also had difficulty with questions involving the relationship between the earth's rotation and seasons, the location of organic material in the soil, and the abundance of gases in the atmosphere.

Physics

- BC students did very well on many of the questions involving light and forces and motion. In the area of light, students did well in topics such as seeing in a dark room, the colour reflecting most light, and why light coloured clothes are cooler. In the area of forces and motion, students did well in questions on the path of a ball released from orbit and balancing on a fulcrum. Students also did well on questions dealing with energy stored in two springs, a diagram of batteries in a flashlight, the transmission of sound on the moon, evaporation rate by surface area, and magnetic substances. Students did not do as well on questions that involved finding the greatest density from a mass/volume table, direction of light rays through a magnifying glass, particles in the nucleus of an atom, and energy stored in food.

Chemistry

- Most questions related to chemical reactivity and transformations were either done very well or done poorly. Among those done very well were questions on the effect of fanning a fire and the best reason for painting iron surfaces. Students did less well on questions involving gas needed for iron to rust and chemical change involving elements.

Environmental and Resource Issues

- BC students did well on some questions involving the conservation of natural resources, in particular one that asked them to identify the area where soil is washed away. They demonstrated limited knowledge of the main cause of acid rain and the results of global warming.

Nature of Science

- Most BC students had difficulty replicating measurements and did not understand formal terms used in the scientific method such *hypothesis*, *observations*, and *conclusions*.

Implications for Instruction

The following are suggestions for instruction in some areas in which students showed weakness. These are not intended to be comprehensive or prescriptive. The purpose is to offer several approaches that could be used to address problem areas, with the expectation that these suggestions would be adapted at a classroom level.

Suggestions for Instruction in Mathematics

- Provide students with opportunities to practice multi-step word problems. Consider having students focus on breaking problems into simpler components first, rather than carrying each problem out to solution. Prior to completing questions of this type, students could be asked questions that focus on strategy or approach: e.g., *What would you do first? What would be the second step?*
- Use a variety of formats when teaching relationships between pairs of numbers. This will address the fact that most students were able to recognize relationships between numbers that were listed as ordered pairs using parentheses but had considerable difficulty when ordered pairs were listed in a table.
- Make frequent use of partitioning for area and volume questions.
- Give greater attention to solving problems that involve finding areas of figures containing excluded regions. Students may find these problems easier if they find the area of the entire region first, and then subtract areas of the excluded regions from the whole.
- Have students work with congruent figures that are oriented differently by first using cardboard or paper replicas that students can manipulate by hand in order to line up corresponding sides and angles. Then present the same figures as stationary diagrams on paper. Using this approach, students could develop skills in spatial visualization.

Suggestions for Instruction in Science

- Give greater attention to topics related to the biology of plant, animal, and other life forms. For example, have students research diet and nutrition and present findings back to the class as a poster session or ask a guest speaker such as a nurse or other health professional to speak to the class about exercise, diet, and disorders of the digestive system.
- Provide greater focus on topics related to the earth's physical features (e.g., erosion and its effect on mountains and the formation of caves). For example, students might examine some weathered rocks and discuss what type of weathering may have occurred; take a field trip to observe different types of rocks and formations.
- Ensure that students know the three states of matter and understand how they can change by heating or cooling. Have them draw diagrams to represent molecules as states change.
- Have students distinguish between elements, compounds, and mixtures. Provide them with samples to classify.
- Provide examples of chemical and physical changes (e.g., cooking, burning, and rusting vs. freezing, melting, evaporating, and dissolving). Have students distinguish between the two types of change and ask them to design experiments, using the scientific method, that demonstrate some of these changes. Once you have approved the experiments, have students perform them.

- Have students research causes and effects of acid rain. They might find out what effects acid rain has on buildings, air quality, and vegetation, and collect data on air quality and how air quality affects the environment, lifestyle, and health.
- Ask students to research the ozone layer. Pose questions such as: *What is it? What impacts on it?* and *What effects can it have on the environment and people?*

Acknowledgements

The Ministry of Education would like to thank Dr. Alan Taylor for the analyses and interpretations of assessment results contained within this publication. Dr. Taylor is a respected mathematics educator, an Adjunct Professor at the University of British Columbia, former director of instruction in Coquitlam School District, and is the National Research Coordinator for TIMSS.

The Ministry of Education wishes to express its appreciation to teachers, administrators, and students involved in the annual Foundation Skills Assessment and national and international assessments. A special thank-you to the following schools that were selected to take part in TIMSS 99 and the 1999 SAIP assessment reported in this publication.

BC Schools Selected for TIMSS 99

Fernie Secondary
Golden Secondary
W L Seaton Secondary
Mount Boucherie Secondary
Chilliwack Middle
Mount Slesse Middle
Abbotsford Junior Secondary
Rick Hansen Secondary
Langley Secondary
Len Shepherd Secondary
Tamanawis Secondary
Pacific Academy
Seaquam Secondary
R C Palmer Secondary
Hugh Boyd Secondary
Lord Byng Secondary
Prince of Wales Secondary
Burnaby South Secondary
Maple Ridge Secondary
Banting Middle
Kwayhquitlum Middle
Scott Creek Middle
St Thomas Aquinas
West Vancouver Secondary
Rockridge Middle
Prince Rupert Secondary
Duchess Park Secondary
Prince George Secondary
Kelly Road Secondary
John McInnis Junior Secondary
Dr Kearney Junior Secondary
Oak Bay Secondary
Dunsmuir Junior Secondary
Spencer Junior Secondary
KVR Middle
Dover Bay Secondary
École Phoenix Middle
Sayward Elementary-Junior Secondary
Campbell River Christian
John Peterson Secondary
Brocklehurst Secondary
Valleyview Secondary
Quamichan Middle
Nisga'a Elementary-Secondary

BC Schools Selected for 1999 SAIP Science Assessment

Elkford Secondary
Sparwood Secondary
David Thompson Secondary
Crawford Bay Elementary-Secondary
J V Humphries Elementary-Secondary
Mount Sentinel Secondary
Trafalgar Junior Secondary
Lucerne Elementary-Secondary
Revelstoke Secondary
J Lloyd Crowe Secondary
Rossland Secondary
Stanley Humphries Secondary
Clarence Fulton Secondary
Dr. Knox Middle
George Elliot Secondary
Glenrosa Junior Secondary
Kelowna Christian
Kelowna Secondary
Okanagan Adventist Academy
Okanagan Mission Secondary
Rutland Secondary
100 Mile House Junior Secondary
Alexis Creek Elementary-Junior Secondary
Anne Stevenson Junior Secondary
Chilliwack Secondary
Mount Cheam Christian
Rosedale Middle
Sardis Secondary
Timothy Christian
Abbotsford Senior Secondary
Career Technical Centre
Rick Hansen Secondary
Robert Bateman Secondary
W J Mouat Secondary
Yale Secondary
Aldergrove Secondary
D W Poppy Secondary
Delphi Academy
Mountain Secondary
Walnut Grove Secondary
Earl Marriott Secondary
Enver Creek Secondary
Frank Hurt Secondary
Guildford Park Secondary
Holy Cross Regional High
Johnston Heights Secondary
L A Matheson Secondary
Lord Tweedsmuir Secondary
North Surrey Secondary
Princess Margaret Secondary
Queen Elizabeth Senior Secondary
Relevant High
Semiahmoo Secondary
Southridge Junior
Surrey Christian
White Rock Christian Academy
Wm Beagle Junior Secondary
Burnsview Junior Secondary
Delta Secondary
North Delta Senior Secondary
Sands Junior Secondary
Tsawwassen Junior Secondary
Cambie Secondary
Hugh McRoberts Secondary
J N Burnett Secondary
Matthew McNair Secondary
Richmond Christian
Richmond Secondary
Steveston Secondary
Britannia Secondary
Crofton House
David Thompson Secondary
Gladstone Secondary
Killarney Secondary
Kitsilano Secondary
Notre Dame Regional Secondary
Point Grey Secondary
Sir Charles Tupper Secondary
St George's
St Patrick's Regional Secondary
Vancouver Christian
Vancouver College
Vancouver Technical Secondary
Windermere Secondary
York House

New Westminster Secondary
Alpha Secondary
Burnaby Central Secondary
Burnaby North Secondary
St Thomas More Collegiate
Haney-Pitt Meadows Christian
Pitt Meadows Secondary
Thomas Haney Centre
Archbishop Carney Secondary
Centennial Senior Secondary
Como Lake Middle
Dr Charles Best Middle
Gleneagle Secondary
Maple Creek Middle
Montgomery Middle
Terry Fox Secondary
Argyle Secondary
Balmoral Junior Secondary
Carson Graham Secondary
Handsworth Secondary
Keith Lynn Junior Secondary
Sutherland Secondary
Vancouver Waldorf
Collingwood
Sentinel Elementary-Secondary
Elphinstone Secondary
Pender Harbour Elementary-Secondary
Brooks Secondary
J P Dallos Middle
Brackendale Junior Secondary
Howe Sound Secondary
Pemberton Secondary
Bella Bella Community
Boundary Central Secondary
Grand Forks Secondary
Charles Hays Secondary
Similkameen Elementary-Secondary
Bulkley Valley Christian
Ebenezer Canadian Reformed
Houston Christian
Smithers Secondary
Cedars Christian
College Heights Secondary
Lakewood Junior Secondary
Mackenzie Secondary
McBride Secondary
Coquihalla Middle
Central Middle Elementary-Junior Secondary
Chetwynd Secondary
South Peace Secondary
Tumbler Ridge Secondary
North Peace Secondary
Prespatou Elementary-Secondary
Upper Pine Elementary-Junior Secondary
Cedar Hill Junior Secondary
Esquimalt Community
Lambrick Park Secondary
Lansdowne Junior. Secondary
Mount Douglas Senior Secondary
Reynolds Secondary
Shoreline Community
Spectrum Community
St Andrew's Regional High
St Michaels University
Parkland Secondary
Stelly's Secondary
Gulf Islands Secondary
Penticton Secondary
Ucluelet Secondary
Barriere Secondary
Kamloops Christian
St Ann's Academy
Kumsheen Elementary-Secondary
Hatzic Secondary
Mission Secondary
Agassiz Elementary-Secondary
Cowichan Secondary
Frances Kelsey Secondary
Queen of Angels
Shawnigan Lake
Caledonia Senior Secondary
Skeena Junior Secondary
Salmon Arm Senior Secondary
Fraser Lake Elementary-Secondary
Nechako Valley Secondary

For further information on the Foundation Skills Assessment and national and international assessments administered in British Columbia, please refer to the Student Assessment and Program Evaluation Branch Web site at www.bced.gov.bc/assessment

You may also contact the branch at:

Phone: (250) 356-2419

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