Pan-Canadian Assessment Program

PCAP 2013

Contextual Report on Student Achievement in Science

cmec
Council of Ministers of Education, Canada
Conseil des ministres de l'Éducation (Canada)

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The Council of Ministers of Education, Canada (CMEC) was formed in 1967 by the jurisdictional ministers responsible for education to provide a forum in which they could discuss matters of mutual interest, undertake educational initiatives cooperatively, and represent the interests of the provinces and territories with national educational organizations, the federal government, foreign governments, and international organizations. CMEC is the national voice for education in Canada and, through CMEC, the provinces and territories work collectively on common objectives in a broad range of activities, including education in early childhood and at the elementary, secondary, and postsecondary levels and adult learning.

Through the CMEC Secretariat, the Council serves as the organization in which ministries and departments of education undertake cooperatively the activities, projects, and initiatives of particular interest to all jurisdictions.[1] One of the activities on which they cooperate is the development and implementation of pan-Canadian testing based on contemporary research and best practices in the assessment of student achievement in core subjects.

Note of appreciation

The Council of Ministers of Education, Canada, thanks the students, teachers, and administrators whose participation in the Pan-Canadian Assessment Program ensured its success. The quality of your commitment has made this study possible. We are truly grateful for your contribution to a pan-Canadian understanding of educational policy and practices in reading, mathematics, and science at the Grade 8/Secondary II level.[2]

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[1] In this report, *ministry* includes departments, and *jurisdictions* include participating provinces and territories.
[2] PCAP is administered to students in Secondary II in Quebec and Grade 8 in the rest of Canada.

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EXECUTIVE SUMMARY

The Pan-Canadian Assessment Program (PCAP) 2013 continues CMEC's commitment to inform Canadians about how well our education systems are meeting the needs of students and society. The information gained from this pan-Canadian assessment provides ministers of education with a basis for examining the curriculum and other aspects of their school systems. PCAP is administered every three years to a sample of more than 30,000 Grade 8 students (Secondary II in Quebec), representing provinces and territories and the two official language groups within these jurisdictions.

Three subjects — reading, mathematics, and science — are assessed in each cycle, with one subject treated as a major domain and the other two as minor domains. The major domain is assessed in greater detail than the minor domains. The major domain was reading in 2007, mathematics in 2010, and science in 2013. This cycle of the three domains will repeat beginning in 2016. In addition to the student tests, questionnaires are administered to students, teachers, and school principals. These questionnaires are designed to measure demographic and socioeconomic factors and to gather information about attitudes, school policies and practices, and teaching and learning strategies.

The results of each assessment are published in two major reports. The first is a public report giving achievement results on the major and minor subjects by jurisdiction, language, and gender. The second, a contextual report, examines achievement in the major domain in relation to variables derived from the questionnaires. This 2013 contextual report focuses on science.

The first two chapters of this report introduce PCAP and briefly summarize the science achievement results reported in the public report. Achievement at or above the Canadian average in science is found in British Columbia, Alberta, Ontario, and Newfoundland and Labrador. There is equity between the anglophone and francophone schools systems in British Columbia, Quebec, and New Brunswick. For those provinces in which there is a significant difference in achievement between the English- and French-language systems in science, students in majority-language systems outperform those in minority-language systems.[3] According to the PCAP 2013 results, in Canada overall, there is no gender difference in achievement in science among Grade 8/Secondary II students. In Canada, 92 per cent of Grade 8/Secondary II students attain at or above the expected level of achievement (level 2 and above) in science. Across jurisdictions, the percentage of Canadian students at or above the expected level of performance ranges from 94 per cent in Alberta and Newfoundland and Labrador to 85 per cent in Manitoba.

Chapter 3 presents the data on five student demographic and socioeconomic (SES) characteristics: gender, language, and student-reported status with respect to SES, immigration, and Aboriginal identity.[4] With respect to the school system's language, students whose first language is the same as the jurisdiction's majority official language achieve higher scores in science compared to those whose first language is the minority official language. There is no significant difference in achievement between students indicating English or another language as their first language. The two indicators of

[3] For the two official languages in Canada, English is the majority language outside of Quebec — 75 per cent of Canadians report speaking English most often at home. In Quebec, French is the majority language —74 per cent report speaking French most often (Statistics Canada, 2011b).

[4] Only students attending schools under provincial jurisdiction participated in this study.

student socioeconomic status used in this study are mother's education and the number of books at home. As PCAP 2013 identified, having a mother with a higher level of education and having more books in the home are both associated with higher performance in science. Immigration status has no significant relationship with science achievement.

Chapter 4 presents information on five student indices that show positive relationships with science performance. Students with high scores in these indices have higher achievement in science: attitude toward science, science self-efficacy, experience with science in the early years, value of science, and understanding of science. One student index related to a student's tendency to fatalism shows a negative relationship with achievement in science. Overall, there is significant variation between the majority- and minority-language groups in Canada. Students in English-language schools have index scores that are similar to those of Canadian students overall but their counterparts in French-language schools have lower scores on the six indices that are shown to have an impact on science achievement.

Chapter 5 looks at characteristics of Canadian Grade 8/Secondary II teachers, including gender, specialization, and professional development. There is a positive relationship between teacher training and student achievement. Higher levels of both formal (education) and informal (experience) training are significantly related to higher student achievement and students achieve higher scores when they are taught by teachers who consider themselves specialists either by education, experience, or by both education and experience. Three types of professional development have a significant, linear relationship with student achievement in the PCAP 2013 science assessment: integrating information technology (IT) into science, academic courses, and improving students' critical thinking or inquiry skills. For these three areas, student achievement is highest in classrooms that are taught by teachers who believe that professional development has an impact on their students' learning. Teacher gender, teachers' years of experience, the amount of a teacher's schedule devoted to teaching science, and the number of days of science-related professional development do not show a significant relationship with student achievement in science.

Chapter 6 examines teachers' instructional practices and beliefs and their relationship with achievement in science. Teachers who believe that they are good science teachers and that they can positively influence student outcomes, regardless of whether or not the student comes from a background that fosters success in school, have higher classroom scores in science. These teachers teach in classrooms with a larger number of students, often use hands-on and collaborative activities (teacher-supported inquiry strategies), and allow their students to express their understanding in a variety of ways. Inquiry education in science has a significant positive relationship with achievement when students receive sufficient scaffolding to support their learning of scientific processes. Although student-directed inquiry activities (in which students design experiments to answer their own questions) are highly motivating for students, a variety of instructional techniques are necessary to move students progressively toward stronger understanding and, ultimately, greater independence in their science learning. Other classroom attributes that are positively associated with achievement in this study include classes that offer some enrichment and those in which fewer student accommodations are required.

Chapter 7 explores issues surrounding time management in schools, including scheduling learning time, homework and out-of-class activities, and time lost for absenteeism and disruptions. Variables that show a positive relationship with achievement are more overall time on homework each week and higher homework effort, not only in science but in all school subjects. When not in school, one in four students are involved with sports or other activities related to their schools or communities for more than six hours weekly and 80 per cent of students participate in such activities for an hour or more a week. Almost 60 per cent of students pursue sport or cultural interests through other lessons each week. The majority of students (about 90 per cent) spend some time each week engaged in technology-related pursuits; however, 20 per cent of students spend more than six hours weekly engaged with technology.

Chapter 8 explores assessment practices in schools and their relationship to achievement in science. Grade 8/Secondary II teachers in Canada use a variety of assessment methods although only the use of performance assessment, including hands-on tasks and other performance-oriented assessments, is positively associated with achievement. Teachers frequently ask their students to develop hypotheses and design investigations — activities that enable students to come to an appreciation of what science is and how it is done in an authentic way. Teachers provide students with guidance regarding expectations, both before completing their assignments in the form of rubrics, and after the work is accomplished in the form of feedback; however, only the use of rubrics is positively associated with achievement. Approximately 80 per cent of students in all jurisdictions indicate that their teachers provide rubrics sometimes or often. Finally, schools reporting that they monitor curriculum implementation and the use of strategies and resources consistent with that curriculum are found to have higher achievement in science.

Chapter 9 presents an overview of Canadian schools that includes demographic information, factors influencing learning, and challenges to teaching. “Characteristics of the student body” is the only factor that is significantly related to achievement at the jurisdiction and population level. Higher achievement is found in schools reporting that this has a greater influence on student learning.

PCAP’s design provides for a research phase that follows the release of the public and contextual reports. A series of reports on more specific topics will follow using more complex analysis techniques, such as multi-level regression modelling, to explore the relationship between all three levels of analysis and to provide a broader picture of the interrelationships between school, teacher, and student variables and achievement in science.

1 WHAT IS THE PAN-CANADIAN ASSESSMENT PROGRAM?

The Pan-Canadian Assessment Program (PCAP) continues CMEC's commitment to inform Canadians about how well our education systems are meeting the needs of students and society. The information gained from this pan-Canadian assessment provides ministers of education with a basis for examining the curriculum and other aspects of their school systems.

School programs and curricula vary from jurisdiction to jurisdiction across the country, so comparing results from these programs is a complex task. However, young Canadians in different jurisdictions learn many similar skills in reading, mathematics, and science. PCAP was designed to determine whether students across Canada reach similar levels of performance in these core disciplines at about the same age, and to complement existing jurisdictional assessments with comparative Canada-wide data on the achievement levels attained by Grade 8/Secondary II students across the country.

Goals

When the ministers of education began planning the development of PCAP in 2003, they set out the following goals for a conceptually new pan-Canadian assessment instrument designed to:

- inform educational policies to improve approaches to learning;
- focus on reading, mathematics, and science, with the possibility of including other domains as the need arises;
- reduce the testing burden on schools through a more streamlined administrative process;
- provide useful background information using complementary context questionnaires for students, teachers, and school administrators; and
- enable jurisdictions to use both national and international results to validate the results of their own assessment programs and improve them.

Development of the assessment

In August 2003, a PCAP working group of experienced and knowledgeable representatives from several jurisdictions (including external expertise on measurement theory, large-scale assessment, and educational policy) began the development process. A concept paper was commissioned to elaborate on issues of structure, development planning, operations, and reporting. Drawing on this concept paper, the working group defined PCAP as a testing program that would:

- be administered at regular intervals to students who are 13 years old at the start of the school year;
- be based on the commonality of all current jurisdictional curricular outcomes across Canada;
- assess reading, mathematics, and science;
- provide a major assessment of one domain, with a minor concentration on the two other domains;

- focus on reading as the major domain in the first administration in 2007, mathematics in 2010, and science in 2013.

Beginning in 2010, PCAP is administered to Grade 8/Secondary II students and, whenever possible, intact classes are selected to minimize the disruption to classrooms and schools.

Table 1.1 provides CMEC's actual and proposed dates for administering PCAP to Canadian Grade 8/Secondary II students.

TABLE 1.1 Actual and proposed PCAP administrations

Domain	Actual or proposed date of PCAP assessment					
	Spring 2007	**Spring 2010**	**Spring 2013**	**Spring 2016**	**Spring 2019**	**Spring 2022**
Major	Reading	Mathematics	Science	Reading	Mathematics	Science
Minor	Mathematics	Science	Reading	Mathematics	Science	Reading
Minor	Science	Reading	Mathematics	Science	Reading	Mathematics

For each subject area, a working group undertook a thorough review of curricula, current assessment practices, and research literature, and wrote reports to indicate the common expectations among all jurisdictions while taking into account assessment initiatives at the international level. Each cycle of PCAP assesses curricular alignment again for the major domain.

The working groups for bilingual framework development, established for each of the three subject areas, were composed of representatives from several jurisdictions with knowledge and experience in curriculum and assessment for the particular subject. Each working group also included external expertise in the assessment of the particular subject to advise and assist with the development of a framework statement establishing the theory, design, and performance descriptors for each domain. All participating jurisdictions reviewed and accepted the framework statements as the basis for test-item development.

Bilingual teams for developing the test items were then established. Members of these teams were subject-area educators selected from all jurisdictions, including subject-assessment expertise. Each subject framework provided a blueprint with its table of specifications describing the sub-domains of each subject area, the types and length of texts and questions, the range of difficulty, and the distribution of questions assessing each specific curriculum expectation.

Texts and questions were developed in both official languages and cross-translated. Curriculum experts and teachers from different regions in Canada reviewed items in both French and English to ensure equivalency in meaning and difficulty. Jurisdictions reviewed and confirmed the validity of the French-to-English and English-to-French translations to ensure fair and equitable testing in both languages.

All new items were reviewed by outside validators and further revised by members of the item-development team. These texts and items were then submitted to the framework-development working group to be examined in light of the blueprint, and field-test booklets were then put together. Booklets contained both selected-response and constructed-response items. Their range of difficulty was deemed accessible to Grade 8/Secondary II students, based on scenarios meaningful to the age group and reflecting Canadian values, culture, and content.

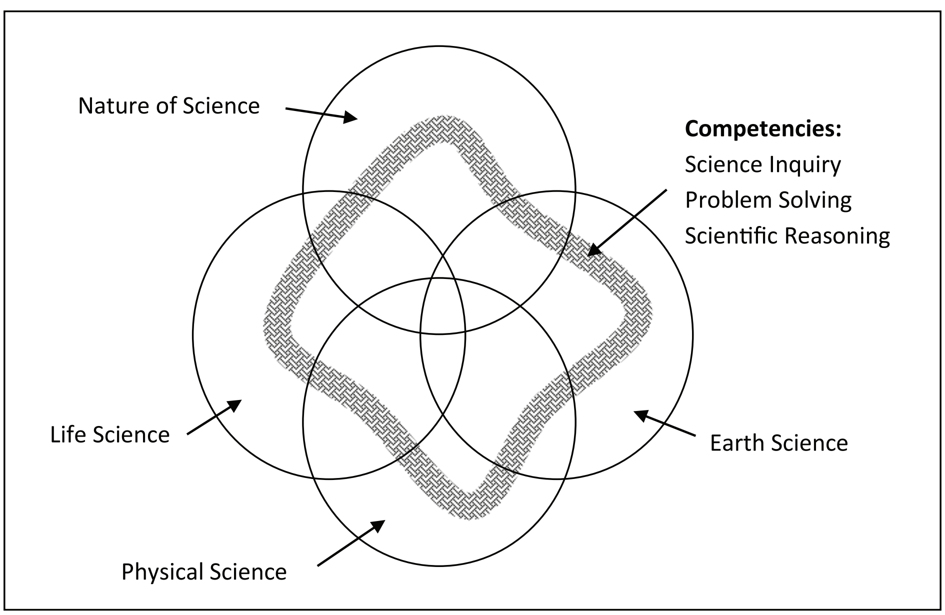
In the spring of 2012, only science items (both newly developed and items donated by jurisdictions) were field tested. Field testing involved administering items in three booklets of comparable difficulty to a representative sample of students from an appropriate range of jurisdictions in both languages. Approximately 2,000 students in 100 schools across Canada were involved in the field testing. Teams of educators from the jurisdictions scored the tests. Following analysis of the data from the field test, all items were reviewed and the texts and items considered best, from a content and statistical viewpoint, were selected to make up four 90-minute booklets. The four booklets for the main study included both field-tested science items and anchor items for reading and mathematics to ensure comparability over time for the minor domains. No anchor items were included for science because this was the first time that science was the major domain and substantive changes to the framework were necessary to reflect the current programs of study across Canada.

General design of the assessment

For PCAP assessment purposes, the domain of science is divided into three competencies (science inquiry, problem solving, and scientific reasoning); four sub-domains (nature of science, life science, physical science, and Earth science); and attitudes, within a given context. Since PCAP Science assesses scientific literacy, each assessment item is coded to both a competency and a sub-domain. Attitude items are embedded within contexts.

The competencies are interwoven throughout the sub-domains of the science assessment because they encompass the means by which students respond to the demands of a particular challenge. The test reflects the current Grade 8/Secondary II science curricula for students in Canadian jurisdictions, as well as the foundation statements in the *Common Framework of Science Learning Outcomes, K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum* (CMEC, 1997).[5] The following diagram represents the organization of PCAP Science as a major domain for assessment.

CHART 1.1 **Organization of subdomains and competencies for PCAP Science**



[5] For updated science curricula, please visit official jurisdictional Web sites.

Each assessment unit presents a scenario or narrative that provides some context for questions, followed by a series of related items. The contexts in the assessment units are intended to captivate the interests of Canadian Grade 8/Secondary II students and therefore to increase their motivation to participate in writing the test. Contexts are introduced through an opening situation and can be in the form of a brief narrative that can also include tables, charts, graphs, or diagrams. Developers of the assessment items ensured that the contexts were developmentally appropriate and not culturally or geographically dependent.

Any text assumes that students will have a degree of reading literacy. In PCAP Science, context selections are chosen to be at a level that is accessible to the vast majority of Grade 8/Secondary II students. This accessibility is determined in two ways. Bilingual committees of experienced educators review and validate the items at each stage of development. Reading indices (Flesch-Kincaid for English texts, and Kandel and Moles for French texts) are used to determine the readability of each assessment unit. The vocabulary is consistent with the level of understanding that can be expected of Canadian students at this level.

Development of assessment booklets

For the PCAP Science assessment, each booklet is composed of eight to ten assessment units that, taken together, span each of the competencies and sub-domains. Each unit includes a scenario and between one and six items. The science units are organized into eight groups or clusters. The eight clusters are distributed within four booklets so that each booklet contains two clusters of science items, one reading cluster, and one mathematics cluster. The four booklets are randomly and equally distributed to students within a single class. While every student completes two of the eight clusters of science assessment items, all eight clusters are completed by students within a given class.

Design and development of contextual questionnaires

The accompanying questionnaires for students, teachers, and schools were designed to provide jurisdictions with contextual information that would contribute to interpreting the performance results. Such information can also be examined and used by researchers, policy-makers, and practitioners to help determine what factors influence learning outcomes.

A questionnaire-development working group made up of educators and research experts from selected jurisdictions developed a framework to ensure that the questions asked of students, teachers, and school principals were consistent with predetermined theoretical constructs or important research questions. The group:

- reviewed questionnaire-design models found in other large-scale assessment programs including the School Achievement Indicators Program (SAIP);[6] Trends in International Mathematics and Science Study (TIMSS); and the Programme for International Student Assessment (PISA);
- maximized research value by shaping the questionnaires around selected research issues for the major domain for each test administration.

[6] SAIP was replaced by PCAP in 2007.

For PCAP 2013, the questionnaires were adapted for science, the major domain.

Administering the PCAP 2013 Science Assessment

In the spring of 2013, the test was administered to a random sample of schools and Grade 8/ Secondary II classes (one per selected school) with a random assignment of booklets within each class.

Sampling and participation

The PCAP populations were defined by the language of the school system for each jurisdiction according to the sampling framework.

Sample size is tied to the numerical size of the population, the margin of error, and the confidence level that is acceptable when statistical compilations are done so that the data can be generalized for the assessed populations. The use of several assessment booklets and the grouping of students by performance levels have a direct impact on the size of the samples. Taking these two parameters into account, the margins of error would have considerable variations. Therefore a sufficiently large number of students was selected to guarantee a margin of error of no more than 3 per cent, with a confidence level of 95 per cent.[7]

This assessment adopted the following stratified sampling process for each population in the selection of participants:

1. the random selection of schools from each jurisdiction, drawn from a complete list of schools under the purview of the ministry of education organized by language of the school system;[8]
2. the random selection of Grade 8/Secondary II classes, drawn from a list of all eligible Grade 8/ Secondary II classes within each school;
3. the selection of all students enrolled in the selected Grade 8/Secondary II class;
4. when intact Grade 8/Secondary II classes could not be selected, a random selection of Grade 8/ Secondary II students.

The sampling process refers to how students were selected to write the assessment. It is necessary to select a large enough number of participants to allow for adequate representation of the population's performance; the word *population* refers to all eligible students within a jurisdiction and/or a linguistic group.

For large populations with sufficient students to allow sampling at first the school and then the class level, the sampling parameter was 150 schools to reach the required number of students. For example, the number of students to be evaluated was 3,300 in anglophone schools in British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario and in francophone schools in Quebec. Since class size is not a parameter in PCAP sampling, the actual number of students sampled may be slightly different

7 For more information on the sampling process, see PCAP 2013 Technical Report, http://www.cmec.ca/511/Programs-and-Initiatives/Assessment/Pan-Canadian-Assessment-Program-(PCAP)/PCAP-2013/Overview/index.html

8 The sample includes both public and private schools.

than this target because the size of the selected classes for PCAP 2013 ranged from fewer than five to more than 30 students.

In the case where numbers of students in a population were smaller than the required size, all schools and/or all Grade 8/Secondary II classes meeting the criteria within the jurisdiction were selected. For example, in Prince Edward Island, all schools were selected with one class participating in each school, whereas all students in the Saskatchewan francophone population participated in PCAP 2013.This approach ensured an adequate number of participants to allow for reporting on their achievement as a statistically valid representation of all students within the jurisdiction.

The sampling process resulted in a very large sample of approximately 32,000 Grade 8/Secondary II students participating in the assessment. All students answered questions in all three domains. Approximately 24,000 responded in English, and 8,000 in French.[9]

Each school received the assessment handbook that outlined the test's purposes, its organization and administration requirements, and suggestions to encourage the maximum possible participation. Administration documents included a common script to ensure that all students encountered the testing process in a similar manner, as well as guidelines for accommodating special-needs students. PCAP testing is intended to be as inclusive as possible to provide a complete picture of the range of performance for students in Grade 8/Secondary II. The students who were excused from participating were nevertheless recorded for statistical purposes. They included those with functional disabilities, intellectual disabilities, socioemotional conditions, or limited language proficiency in the assessment's target language.

Participation rates

In large-scale assessments, participation rates are calculated in a variety of ways and are used to guide school administrators when determining whether the number of students who completed the assessment falls within the established norm set for all schools. PCAP provides a formula to the test administrators for this purpose, thereby assuring that all schools use the same guidelines and that the set minimum of participating students is uniformly applied. Using this formula, the PCAP student participation rate was close to 90 per cent Canada-wide. For additional information concerning the student participation and sampling, refer to chapter 2.

Schools were encouraged to prepare and motivate students for the test, aiming for participation that was positive and engaged by teachers and students. The provided materials included information pamphlets for parents and students as well as the school handbook.

Schools were also asked to have the teacher questionnaire completed by all the science teachers of the participating students in the school, and the school questionnaire by the school principal. All questionnaires were linked to student results but used unique identifiers to preserve confidentiality.

Scoring the student response booklets

The scoring was conducted concurrently in both languages in one location over a three-week period in the summer of 2013. After all student booklets had been submitted from the jurisdictions, the booklets were then scrambled into bundles so that any single bundle contained booklets from several

[9] French immersion students are included with the anglophone populations but their class could write the assessment in either English or French.

jurisdictions. The scoring-administration team, the table leaders, and the scorers themselves came from several jurisdictions. The whole scoring process included:

- a team of scorer leaders for each subject area who were responsible for reviewing all instruments and selecting sample and training tests to ensure comparability at every level;
- parallel training of both table leaders and scorers in each subject area;
- twice-daily rater-reliability checks in which all scorers marked the same student work to track the consistency of scoring on an immediate basis;
- double scoring in which a sample of each of the four booklets was rescored, providing an overall inter-rater reliability score; and
- rescoring anchor items in which a sample of student responses for each item administered in a previous assessment was rescored to track the consistency of scoring between test administrations.

The PCAP 2013 public report, *PCAP 2013 — Report on the Pan-Canadian Assessment of Science, Reading, and Mathematics* (O'Grady & Houme, 2014) presented detailed performance results.

Statistical Note

Samples. The results presented in this report are based on samples. Separate samples were selected for each jurisdiction (province or territory) and for anglophone and francophone populations within each jurisdiction. Some of the francophone samples were quite small. Because statistics such as percentages or means are quite unstable for small samples, it was necessary to combine the two language groups in some jurisdictions when reporting results at the jurisdictional level. For student results, the language groups were combined for Prince Edward Island and Newfoundland and Labrador. Students in French immersion programs were considered part of the anglophone population. When pan-Canadian results were computed, all students, schools, and teachers were assigned to their appropriate language group.

Confidence intervals. The results from the samples are estimates of those that would have been achieved had all members of the populations been included in the assessment. The actual results may differ from their population values for a variety of reasons, including sampling error or the relative unreliability in responses to test or questionnaire items. It is common practice in research of this nature to report a range within which the actual population value is expected to fall. This range is known as a confidence interval. Confidence intervals are reported in tables as a number with a ± (plus or minus) sign that represents the range above or below the reported value in which the population value is expected to be found with a specified level of probability, typically 95 per cent. Confidence intervals are represented in bar graphs by error bars that correspond to the 95 per cent confidence interval above and below the number given by the bar. We can say that the population value would be expected to be within the range represented by the total width of the error bars, 95 times out of 100.

Statistical significance. When making comparisons between groups (such as the difference in mean science scores for jurisdictions), the difference is said to be statistically significant if it is greater than the sum of the two confidence intervals. For graphical presentations, a difference can be considered statistically significant if the error bars for the compared groups do not overlap. To keep the graphs as simple as possible in this report, statistical significance is indicated mainly for comparing mean science scores and index quarters across groups, and for regression coefficients.

Weights. The ratio of population to sample size gives a statistic called the weight, which is applied when results are combined across groups. This ensures that each population or sub-population is represented in the combined results in proper proportion to its size. All results given in this report use weighted data so the results can be said to represent the whole population. However, error computations are based on actual sample sizes because errors are strongly related to sample size.

Populations and samples

The sampling process was described in chapter 1. Table 2.1 gives the student, school, and teacher sample sizes for each jurisdiction and the official-language groups within jurisdictions. The small sample sizes for some of the francophone populations led to a decision to combine the language groups in Prince Edward Island and Newfoundland and Labrador.

All students wrote all three domains of the assessment, and they all completed the questionnaires, so all student results are based on the complete sample.

TABLE 2.1 **Samples**[10]

	Student Sample	School Sample	Teacher*
British Columbia (E)	3,322	150	297
British Columbia (F)	188	12	15
Alberta (E)	2,720	137	140
Alberta (F)	342	19	25
Saskatchewan (E)	3,333	184	200
Saskatchewan (F)	97	7	9
Manitoba (E)	3,542	150	168
Manitoba (F)	367	18	22
Ontario (E)	3,208	149	155
Ontario (F)	2,180	125	127
Quebec (E)	1,750	83	123
Quebec (F)	3,681	149	161
New Brunswick (E)	1,768	78	110
New Brunswick (F)	999	55	57
Nova Scotia (E)	2,402	126	128
Nova Scotia (F)	314	11	18
Prince Edward Island (E)	704	22	40
Prince Edward Island (F)	39	3	3
Newfoundland and Labrador (E)	1,641	114	118
Newfoundland and Labrador (F)	7	2	1
Canada	**32,604**	**1,594**	**1,917**

* All teachers who taught science to students writing the PCAP test in a school were sampled. Because intact classes were used, one teacher was sampled in most schools. In some large schools, more than one class was sampled. Some science classes were taught by two or more teachers.

10 Actual numbers may be lower because of missing data. Only students with both achievement and questionnaire data are included in the analysis and not all teacher and school questionnaires were submitted.

Scaling

Following the initial scoring process, as chapter 1 describes, scores were scaled to a mean of 500 and a standard deviation of 100 for Canada. This provides a relatively simple basis for comparing groups. On this type of scale, approximately two-thirds of the individual student scores will fall within plus or minus one standard deviation of the mean, or between 400 and 600. This was the first cycle in which science was the main focus and will be used as the baseline for comparisons over time for later cycles.

Terminology used in the charts and tables

Differences

In this report, the terms *difference* or *different* used in the context of achievement results refer to a difference in a technical sense. They refer to a *statistically significant difference*. A difference is statistically different when there is no overlap of confidence intervals (CI) between different measurements. In this report, if there is a significant difference between two mean scores with their confidence intervals, the difference is indicated using an asterisk (*).

Confidence intervals

In this assessment, the reported mean scores provide estimates of the achievement results students would have demonstrated if all students in the population had participated in the assessment. In addition, a degree of error is associated with the scores describing student skills. This error is called the *error of measurement.* Because an estimate based on a sample is rarely exact, and because the error of measurement exists, it is common practice to provide a range of scores for each jurisdiction within which the actual achievement level might fall. This range of scores expressed for each mean score is called a *confidence interval.* A 95 per cent confidence interval is used in this report to represent the high- and low-end points between which the actual mean score should fall 95 per cent of the time.

In other words, one can be confident that the actual achievement level of all students would fall somewhere in the established range 19 times out of 20 if the assessment were drawn from the same student population. In the charts in this report, confidence intervals are represented by this symbol: . If the confidence intervals overlap, the differences are typically defined as not statistically significant. When the confidence intervals overlap slightly, an additional test of significance (t-test) is conducted to determine whether the difference is statistically significant. For comparisons between pan-Canadian and jurisdictional results, the Bonferroni adjusted t-test was performed. This correction is used to reduce the rate of false positive (or type I) errors.

Comparisons between results for English and French

Caution is advised for comparing achievement results, even though assessment instruments were prepared collaboratively with due regard for equity for students in both language groups. Every language has unique features that are not readily comparable. While the science items, performance descriptors, scoring guides, and processes were judged equivalent in English and French, pedagogical, cultural, and geographical differences related to differences in language structure and use render direct comparisons between language groups inherently difficult. Any such comparisons should be made with caution.

Overview of achievement results in science

Table 2.2 gives mean science scores for the jurisdictions. It shows that Alberta and Ontario students perform at a level significantly above the Canadian average and those in British Columbia and Newfoundland and Labrador are at the Canadian average, while students in all other jurisdictions perform below the Canadian average.

TABLE 2.2 **Results in science by jurisdiction**

	Mean score	CI	Difference compared to CAN*
BC	501	4.2	
AB	521	4.9	*
SK	486	4.2	*
MB	465	3.1	*
ON	511	4.5	*
QC	485	3.6	*
NB	469	3.7	*
NS	492	3.6	*
PE	491	5.0	*
NL	500	4.3	
CAN	**500**	**1.9**	

* denotes significant difference

Table 2.3 presents the two official-language groups' results for each jurisdiction that sampled students in the English and French school systems separately in sufficient numbers for a valid statistical comparison. There is no difference in achievement between the two language systems in British Columbia, Quebec, and New Brunswick. For Canada overall and for jurisdictions where there was a difference between the two systems, students enrolled in anglophone schools are performing at a level that is statistically higher than those enrolled in francophone schools.

Table 2.3 **Achievement in science by jurisdiction and by language**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	501	4.3	495	7.8	6
AB	521	4.2	488	4.9	33*
SK	486	4.5	474	1.6	12*
MB	465	3.5	452	3.6	13*
ON	513	5.1	464	4.0	49*
QC	484	5.0	485	3.7	1
NB	467	3.7	475	5.1	8
NS	493	4.2	466	3.8	27*
PE	492	5.2	--	--	--
NL	500	4.8	--	--	--
CAN	**505**	**2.3**	**483**	**2.6**	**22***

* denotes significant difference

Achievement by performance level in science

Another way of looking at science performance is to establish proficiency levels based on descriptions of what students can do at each level. For the PCAP Science Assessment, four proficiency levels were defined, with level 2 considered the acceptable level of performance for Grade 8/Secondary II students.[11] The data for performance levels appear in table 2.4 as the percentage of students who obtain a score within the range of scores attributed to each of the four specific levels.

In Canada, 92 per cent of Grade 8/Secondary II students attain at or above the expected level of achievement (level 2 and above) in science (table 2.4). Across jurisdictions, the percentage of Canadian students at or above the expected level of performance ranges from 94 per cent in Alberta and Newfoundland and Labrador to 85 per cent in Manitoba.

In Alberta and Ontario more than 50 per cent of students achieve above the expected level of performance in science, and more than 40 per cent of students achieve above the expected level in British Columbia, Saskatchewan, Quebec, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Indeed, 10 per cent or more of students in Alberta and Ontario achieve performance level 4, the most advanced level. In other jurisdictions, the proportion of students achieving level 4 varies between 9 per cent in British Columbia and 4 per cent in Manitoba and New Brunswick.

No more than 15 per cent of students in any jurisdiction perform below the acceptable level. However, the range for level 1 performance varies considerably, from 6 per cent in Alberta and Newfoundland and Labrador to 15 per cent in Manitoba.

[11] For details on the performance level definitions, please see the PCAP 2013 public report (O'Grady & Houme, 2014).

TABLE 2.4 **Distribution of students by level of performance in science**[12]

	Level 1		Level 2		Level 3		Level 4		Level 2 & above		Difference compared to CAN
	%	CI	%	CI	%	CI	%	CI	%	CI	
BC	9	1.0	43	2.0	39	1.8	9	1.2	91	1.1	
AB	6	1.2	37	2.2	44	2.4	12	1.4	94	1.2	*
SK	11	1.2	47	1.8	35	1.6	6	0.8	89	1.4	*
MB	15	1.4	53	2.0	29	1.4	4	0.6	85	1.1	*
ON	7	1.0	41	2.0	43	2.0	10	1.2	93	1.1	
QC	9	1.0	50	1.8	36	1.6	5	0.8	91	1.2	
NB	13	1.2	52	1.8	31	1.8	4	0.8	87	1.4	*
NS	9	1.2	48	2.4	37	1.6	6	1.0	91	1.3	
PE	7	1.4	50	2.5	37	2.7	6	1.2	93	1.5	
NL	6	1.0	47	2.2	39	2.4	8	1.2	94	1.3	*
CAN	**8**	**0.4**	**44**	**1.0**	**39**	**1.0**	**8**	**0.6**	**92**	**0.5**	

* denotes significant difference

Students' level of science performance by language

Table 2.5 presents the percentage of students at each performance level reported by language of the school system students are enrolled in. The proportion of students who achieve level 2 and above is the same in the French- and English-language systems in Canada. However, there is a higher percentage of students achieving at performance levels 3 and 4 in English-language schools than in French-language schools. A higher proportion of students meet or exceed the expected level or performance in science in anglophone schools in Alberta and Newfoundland and Labrador and francophone schools in British Columbia compared to the average proportions in Canadian anglophone and francophone schools. A significantly lower proportion of students in anglophone schools in Saskatchewan, Manitoba, and New Brunswick and francophone schools in Saskatchewan, Manitoba, Ontario, and Nova Scotia meet or exceed the expected level or performance in science compared to the respective Canadian proportions.

[12] Totals may not sum to exactly 100 per cent because of rounding.

Table 2.5 **Distribution of students by performance level by language of the school system**

	Level 1		Level 2		Level 3		Level 4		Level 2 & above		Difference compared to CAN
	%	CI	%	CI	%	CI	%	CI	%	CI	
Anglophone schools											
BC	9	1.2	43	1.8	39	2.0	9	1.0	91	1.3	
AB	6	1.0	37	2.2	45	2.2	12	1.4	94	1.1	*
SK	11	1.6	47	1.8	35	2.0	6	0.8	89	1.5	*
MB	14	1.4	53	1.8	29	1.8	4	0.6	86	1.2	*
ON	7	1.0	40	2.0	43	2.2	10	1.4	93	1.1	
QC	9	1.4	50	2.7	36	2.7	5	1.0	91	1.1	
NB	14	1.4	51	2.0	30	2.4	4	1.0	86	1.7	*
NS	9	1.0	48	2.0	37	2.4	6	1.0	91	1.1	
PE	7	1.4	50	2.9	37	2.4	6	1.2	93	1.7	
NL	6	1.0	47	2.4	39	2.4	8	1.4	94	1.2	*
CAN	**8**	**0.6**	**42**	**1.2**	**41**	**1.2**	**9**	**0.8**	**92**	**0.6**	
Francophone schools											
BC	6	2.0	50	4.3	38	3.9	6	1.8	94	2.0	*
AB	10	1.4	46	2.4	39	2.2	5	0.8	90	1.4	
SK	11	0.6	51	1.2	35	1.0	3	0.2	89	0.7	*
MB	16	1.4	56	2.0	26	1.6	2	0.4	84	1.5	*
ON	16	1.8	50	2.2	31	2.2	3	0.8	84	1.8	*
QC	9	1.0	50	2.0	36	1.6	5	0.8	91	1.0	
NB	10	1.8	53	2.9	34	3.1	3	0.8	90	1.6	
NS	12	1.2	57	2.0	29	2.2	2	0.6	88	1.5	*
CAN	**9**	**1.0**	**50**	**1.6**	**36**	**1.6**	**4**	**0.6**	**91**	**0.9**	

* denotes significant difference

Students' level of science performance by gender

In Canada overall, there is no gender difference in achievement in science at Grade 8/Secondary II, as table 2.6 shows. Compared to the Canadian mean for female students, a significantly lower proportion of female students in Saskatchewan, Manitoba, and New Brunswick meet or exceed the expected level or performance in science. A significantly lower proportion of male students in Manitoba and New Brunswich achieve level 2 and above compared to their Canadian counterparts.

TABLE 2.6 **Distribution of students by level of performance by gender**

	Level 1		Level 2		Level 3		Level 4		Level 2 & above		Difference compared to CAN
	%	CI	%	CI	%	CI	%	CI	%	CI	
Females											
BC	8	1.2	43	2.7	39	2.5	9	1.6	92	1.4	
AB	6	1.4	37	2.7	45	2.7	13	1.8	94	1.4	
SK	12	1.6	49	2.7	33	2.0	6	1.2	88	1.6	*
MB	15	2.0	53	2.5	28	2.4	4	0.8	85	1.9	*
ON	6	1.4	43	2.7	42	2.5	9	1.4	94	1.3	
QC	9	1.2	50	2.0	36	2.4	5	1.2	91	1.4	
NB	11	1.6	53	2.5	32	2.4	4	0.8	89	1.8	*
NS	8	1.4	50	2.9	35	2.5	6	1.2	92	1.6	
PE	6	1.8	51	3.9	36	3.7	7	1.6	94	1.8	
NL	6	1.6	47	3.5	39	3.5	8	2.0	94	1.5	
CAN	**8**	**0.8**	**45**	**1.4**	**39**	**1.4**	**8**	**0.8**	**92**	**0.6**	
Males											
BC	10	1.8	42	2.5	38	2.4	9	1.4	90	1.8	
AB	7	1.4	38	2.7	44	2.9	11	1.8	93	1.6	
SK	10	2.4	46	2.7	38	2.9	6	1.2	90	2.6	
MB	14	1.8	52	2.7	29	2.5	4	0.8	86	1.7	*
ON	8	1.8	38	2.7	43	2.9	10	1.8	92	1.8	
QC	8	1.4	51	2.4	36	2.2	4	0.8	92	1.4	
NB	15	1.8	50	2.4	31	2.2	4	1.2	85	1.7	*
NS	9	1.6	46	2.7	38	2.4	6	1.4	91	1.8	
PE	7	2.4	48	3.5	38	4.1	6	1.6	93	2.6	
NL	7	1.6	47	3.9	39	3.1	8	2.0	93	1.7	
CAN	**9**	**0.6**	**43**	**1.4**	**40**	**1.2**	**8**	**0.8**	**91**	**0.7**	

* denotes significant difference

Summary

In British Columbia, Alberta, Ontario, and Newfoundland and Labrador students achieve at or above the Canadian average in science.

Equity in achievement between anglophone and francophone school systems is found in British Columbia, Quebec, and New Brunswick. For those provinces where there is a significant difference in achievement between the English- and French-language systems in science, students in majority-language systems outperform those in minority-language systems. A significantly higher proportion of students enrolled in anglophone schools in Alberta and Newfoundland and Labrador and in francophone schools in British Columbia meet or exceed the expected level of performance in science compared to the respective Canadian means. Compared to their Canadian counterparts, a significantly lower proportion of students enrolled in anglophone schools Saskatchewan, Manitoba, and New Brunswick and francophone schools in Manitoba and Ontario achieve at or above expected levels of performance.

In Canada overall, there is no gender difference in achievement in science at Grade 8/Secondary II according to PCAP 2013. A higher proportion of females in Ontario meet or exceed the expected level of performance in science compared to Canadian female students overall. Compared to the Canadian averages, lower proportions of female students in Saskatchewan, Manitoba, and New Brunswick and male students in Manitoba and New Brunswick achieve at or above expected levels of performance.

3 STUDENT DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS

Certain demographic and socioeconomic characteristics of students are considered as stable attributes of individuals. These include: gender, language, socioeconomic status, immigration status, and Aboriginal status. For each variable, this chapter reports descriptive results by province and by language group and then its relationship with science achievement is presented for Canada overall. Results are also compared with data from previous PCAP and international assessments, when available.

Gender

Policy-makers have an interest in reducing gender disparities in education. Student motivation and interest in school can have a significant impact on their later career choices and salary prospects. A number of studies have shown that girls exhibit steeper and more sustained decreases in interest in science than boys from elementary to middle and high school (Greenfield, 1997; Lupart, Cannon, & Telfer, 2004). Girls believe they have to work harder at science than boys, and prefer to avoid it in favour of reading and language arts (Andre et al., 1999; Ford et al., 2006; Lupart Cannon, & Telfer, 2004). According to Statistics Canada (2013b), young women attending university are less likely than young men to choose a program in science, technology, engineering, mathematics, and computer science (STEM), regardless of their mathematical ability in high school. Generally, because women do not find scientific careers attractive, science remains a male-dominated field (Ceci, Williams, & Barnett, 2009; Eccles, 2007 in Ceci & Williams 2007; Lupart Cannon, & Telfer, 2004; Stake, 2006).

Chart 3.1 gives the gender distribution (or percentage) of students by province. Some minor variations exist at the level of populations as shown in Table 3.1. Particularly for smaller populations, such variances may be partly a result of the whole-class sampling process used in PCAP.

CHART 3.1 **Distribution of students by gender and jurisdiction**[13]

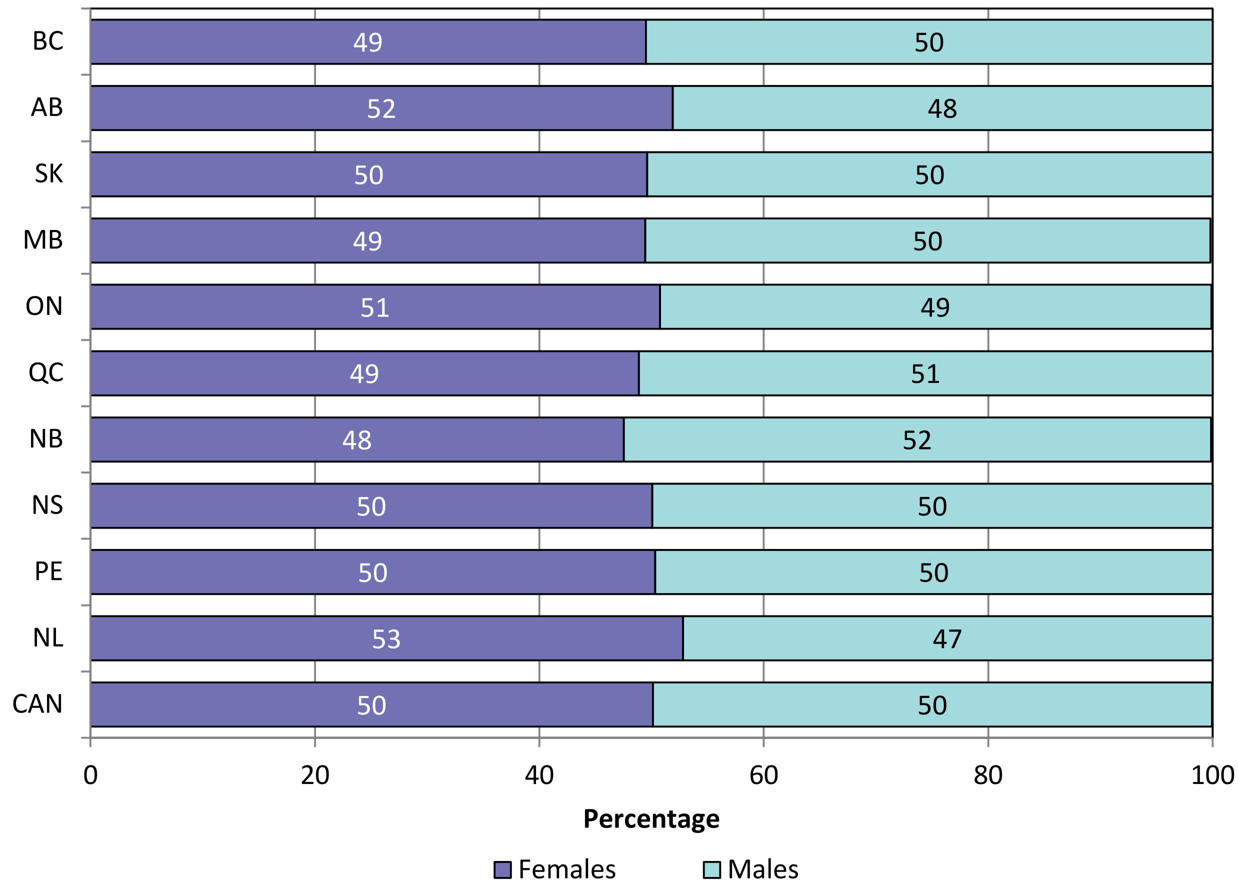


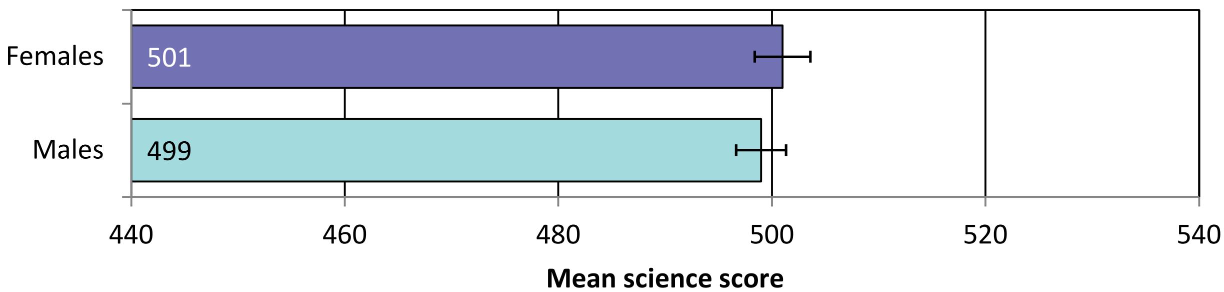
TABLE 3.1 **Distribution of students by gender and population**

	Anglophone schools		**Francophone schools**	
	Females	**Males**	**Females**	**Males**
BC	50	50	55	45
AB	52	48	49	51
SK	50	50	54	46
MB	48	51	49	51
ON	51	49	51	49
QC	49	51	50	50
NB	46	54	52	48
NS	50	50	56	44
PE	51	49	--	--
NL	53	47	--	--
CAN	**50**	**50**	**51**	**49**

[13] Totals may not sum to exactly 100 per cent because of rounding.

Performance in science in Grade 8/Secondary II in PCAP 2013 is remarkably similar between boys and girls in Canada, as chart 3.2 shows, and confirms findings from international studies such as PISA (Brochu, Deussing, Houme, & Chuy, 2013; Statistics Canada, 2013b) and TIMSS (Martin, Mullis, Foy, & Stanco, 2012). Thus, if Canadian women are less likely to choose a science program during their postsecondary studies, it is not necessarily because of differences in academic performance. It is important that policy-makers continue to work to reduce gender disparities with respect to interest in science, technology, engineering, and mathematics (STEM) to ensure Canada's ability to fully participate in the global knowledge economy.

CHART 3.2 **Achievement in science by gender**



Language

Canada is a multilingual and multicultural country with various immigrant and Aboriginal populations. The two official languages of instruction in Canada are English and French but the majority of students receive their first-language instruction in English. To ensure that all students have the opportunity to learn both of Canada's official languages, French immersion programs are offered in the public education systems throughout Canada.[14] Also, to support Aboriginal and immigrant populations, a variety of language programs are available in some provinces, where English and/or French are taught in addition to other languages. Manitoba, for instance, offers 10 different language classes including Cree and Ojibwe, in addition to bilingual programming in English-German, English-Hebrew, and English-Ukrainian.[15]

The PCAP populations were defined by the language of the school system for each jurisdiction according to the sampling framework, and the tests were written in English or French accordingly. As part of the contextual questionnaire, students were asked in what language most of their school subjects are taught: English, French, Aboriginal (e.g., Cree, Inuktitut), or other (e.g., German, Mandarin). In Canada overall, 70.1 per cent of the PCAP population receives instruction in English and 29.6 per cent in French. A small proportion of students report that they receive most of their instruction in Aboriginal languages (0.1 per cent) and other languages (0.2 per cent).[16] As the sampling framework expected, Quebec is the only province where French language instruction is more common than English language instruction (89.6 per cent compared to 10.1 per cent respectively), and New Brunswick is the only province where the two language groups are equally represented

[14] For a more detailed description of language policies in Canada, see Chuy (Mullis et al. 2012b).

[15] For further information, see International and Heritage Languages on the ministry Web site at http://www.edu.gov.mb.ca/k12/cur/languages/index.html

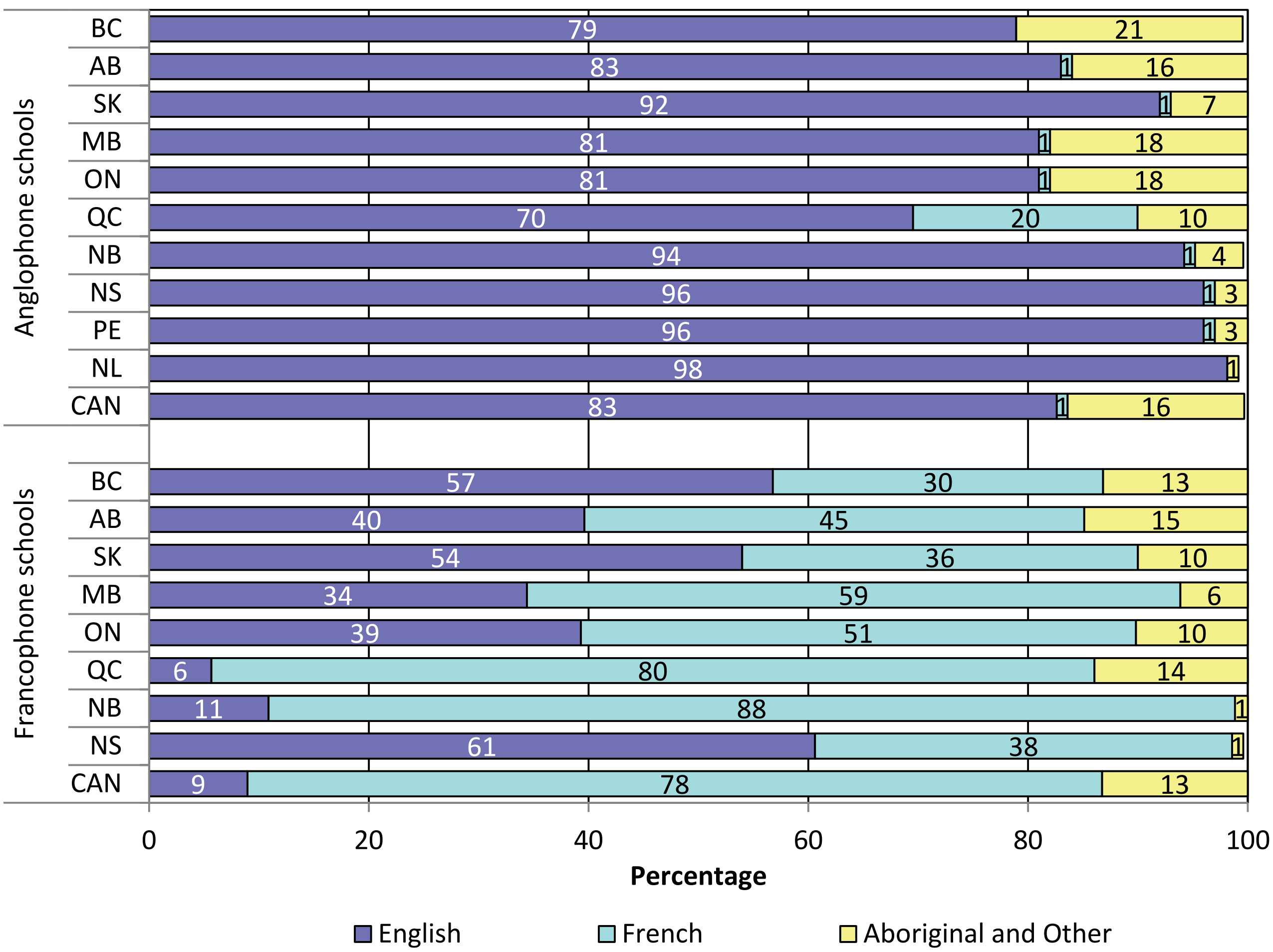
[16] Care must be taken when interpreting student self-reported data because they may not always match administrative data sources.

(50.4 per cent versus 49.3 per cent). The proportion of Aboriginal and other languages is below 1 per cent for all provinces and for Canada overall.

Canada has a significant and increasing immigrant population. Some large urban areas identify more than 75 different home languages and dialects among students. In PCAP 2013, students were asked to identify their mother tongue, as well as the language they use in everyday life (e.g., with family, friends, or in the community).

Mother tongue was defined in the questionnaire as the language students first learned and still understand. As chart 3.3 shows, the distribution of students' first language is quite different in French- and English-speaking jurisdictions. While the vast majority of students indicate English as their mother tongue in all anglophone jurisdictions, only two francophone jurisdictions have French as a dominant language: New Brunswick and Quebec. In Manitoba and Ontario, only about half of all students attending francophone schools consider French their mother tongue. In other francophone jurisdictions, this proportion is even less than half, with the lowest percentage observed in British Columbia French (30 per cent).

CHART 3.3 **Distribution of students by their first language and by language of the school system**[17]



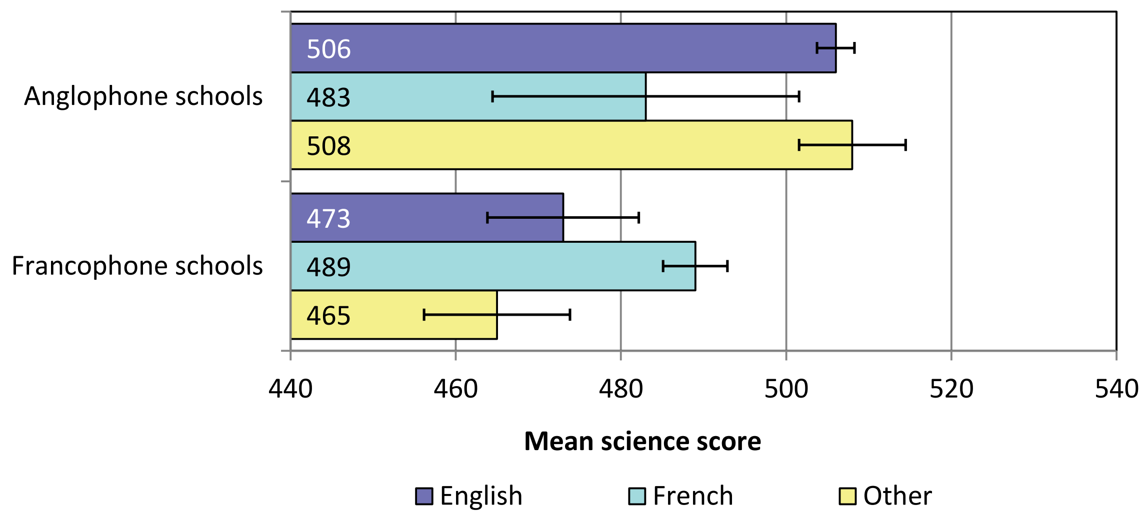
Note: Owing to the small sample size, percentages for Aboriginal students and for francophone students participating in Prince Edward Island and Newfoundland and Labrador are not indicated separately in this chart.

[17] Totals may not sum to exactly 100 per cent because of rounding.

Analysis of science achievement by first language shows different results for anglophone and francophone school systems (chart 3.4).

- *Anglophone school system*: Students whose first language is French perform at a level lower than students having English or "other" as their first language. There is no significant difference between the English and "other" language groups.
- *Francophone school system*: Students with French as their first language have higher achievement scores in science than those with English or "other" as their first language. There is no significant difference in achievement between students indicating English or "other" as their first language.

CHART 3.4 **Relationship between students' first language and science achievement**



Note: Owing to the very small sample size, percentages for Aboriginal languages are not indicated in this chart.

Students may master several languages and the language of the school may not be the same as that used outside the school (e.g., with family, friends, or in the community). Table 3.2 shows the proportion of students by the language they speak in their everyday lives at the provincial level. The provinces of Quebec and New Brunswick stand out for having the highest proportion of students who speak both official languages outside the school (31 per cent and 27 per cent respectively). Quebec (19 per cent) and Manitoba (18 per cent) have the highest proportion of students who mostly use a language other than English or French. At the population level, a much higher proportion of students speak both official languages and other languages in francophone schools in most jurisdictions (table 3.3).

Table 3.2 **Percentages of students by the language they use in their everyday lives**[18]

	English	French	Both English and French	English and a language other than French	French and a language other than English	Mostly other languages
BC	92	1	6	45	1	16
AB	91	1	6	29	1	14
SK	95	1	6	18	2	7
MB	90	2	8	31	2	18
ON	89	2	7	39	2	14
QC	15	74	31	18	23	19
NB	75	23	27	11	5	4
NS	96	2	10	12	1	4
PE	97	2	11	6	1	1
NL	99	1	6	7	1	2
CAN	**75**	**22**	**13**	**31**	**7**	**15**

[18] Since students could check more than one category for this question, the percentages add up to over 100 per cent. The results on science achievement are not available for these type of data.

Table 3.3 **Percentages of students by the language they use in their everyday lives and by language of the school system**

	English	French	Both English and French	English and a language other than French	French and a language other than English	Mostly other languages
Anglophone schools						
BC	92	1	5	45	1	16
AB	91	1	6	30	1	14
SK	95	1	5	18	2	6
MB	91	1	7	32	2	18
ON	91	1	4	39	1	14
QC	75	17	43	33	5	8
NB	94	3	14	11	1	5
NS	97	1	7	12	0	4
PE	98	1	8	6	1	1
NL	99	1	6	7	1	2
CAN	**91**	**2**	**6**	**35**	**1**	**13**
Francophone schools						
BC	65	19	62	31	17	23
AB	50	26	57	28	15	19
SK	75	25	56	22	18	19
MB	49	29	70	16	13	10
ON	54	23	61	24	15	17
QC	8	79	30	17	25	20
NB	14	66	56	10	13	3
NS	65	22	57	20	11	7
CAN	**13**	**74**	**33**	**17**	**24**	**19**

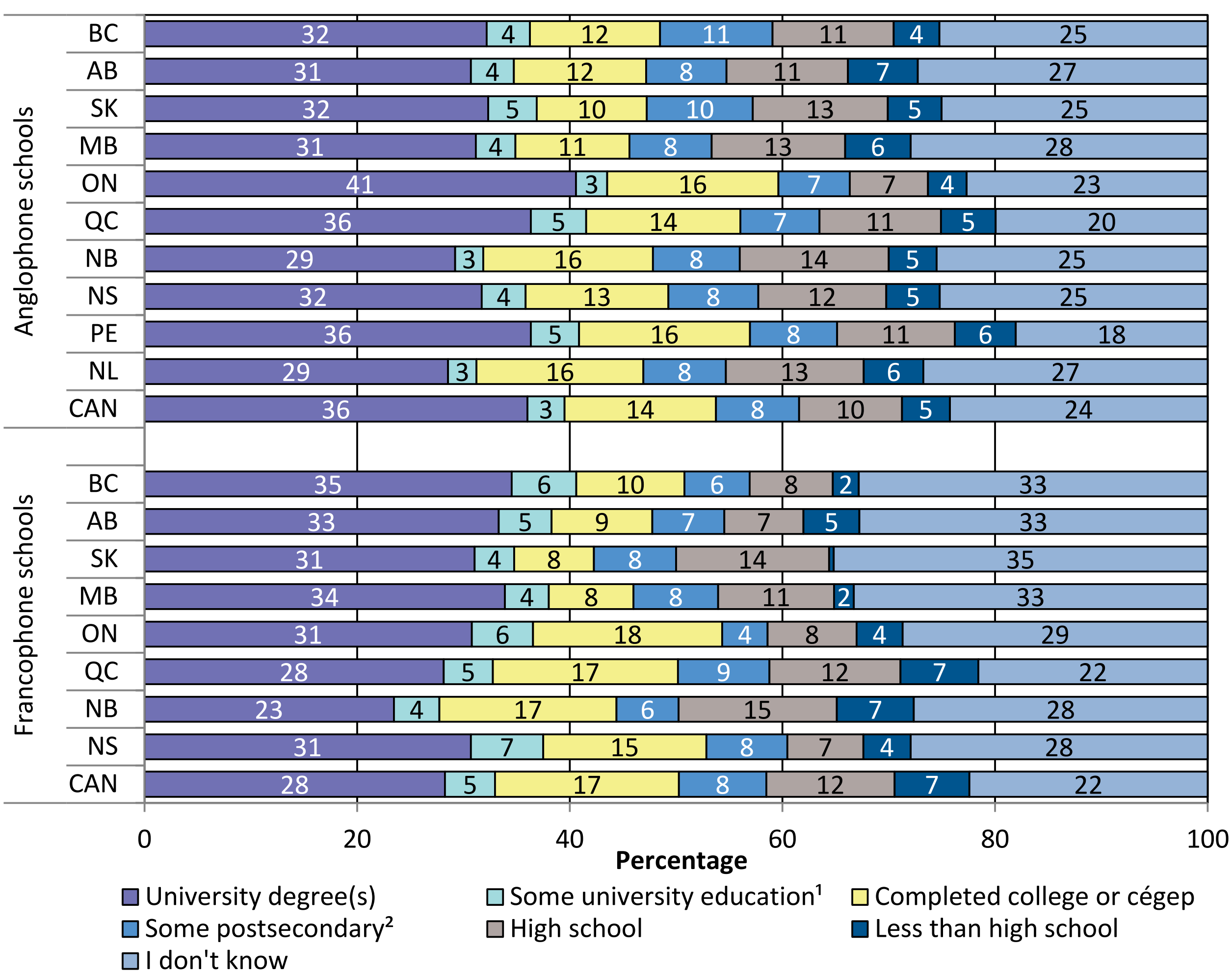
Student socioeconomic status

Socioeconomic status (SES) remains one of the strongest predictors of academic achievement, whether it's in science, mathematics, or reading (see Sirin, 2005 for a review). According to the latest PISA data, on average across OECD countries, socioeconomically disadvantaged students are twice as likely to be among the poorest performers in reading compared to advantaged students (OECD, 2013a). Canada is generally listed among the countries and economies with the greatest equity in students' outcomes, based on the relatively lower influence of SES on achievement. It remains one of the top performers. Based on PISA 2009 results in reading, the performance gap between socioeconomically advantaged and disadvantaged students is 21 PISA points narrower in Canada than across other OECD countries (gap of 67 vs. 88 points, for Canada and OECD respectively).

Several indicators of socioeconomic status can be found in the literature, but there seems to be ongoing discussions regarding their use in educational research (Bornstein & Bradley, 2003). PISA, for instance, calculates the *index of economic, social, and cultural status* based on the three indices: highest occupational status of parents, highest educational level of parents, and home possessions (including family wealth, home educational resources, cultural possessions, and number of books in the home) (OECD, 2013b). In the PCAP 2013 student questionnaire, two indicators of student socioeconomic status were included: mother's education and the number of books at home.

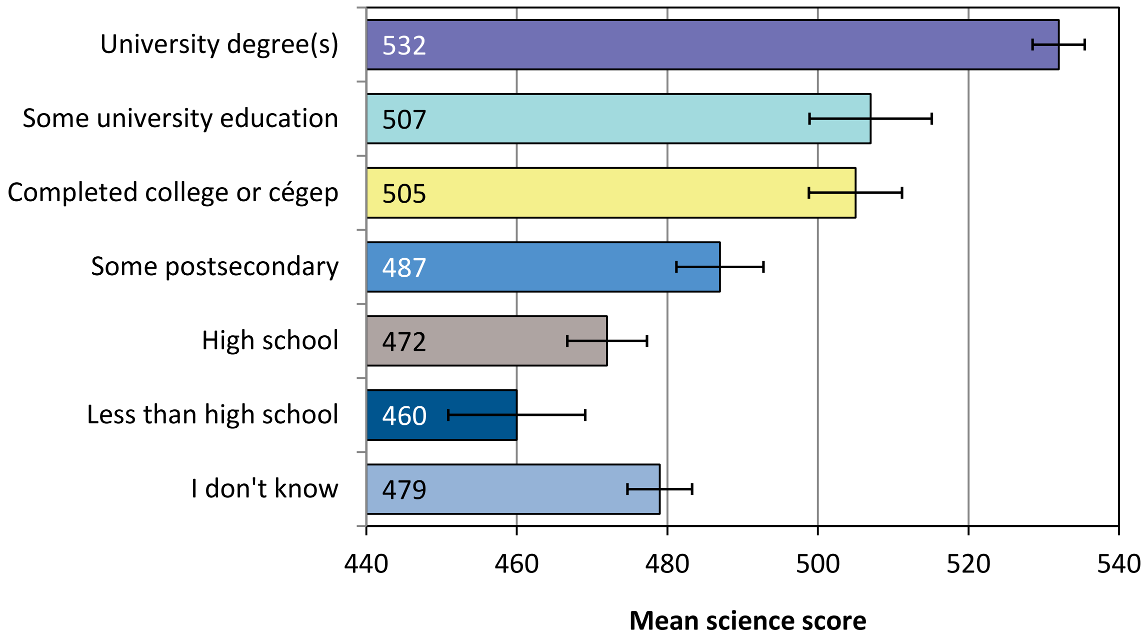
Mothers' education has a major influence on students' achievement. Generally, less-educated parents hold lower educational expectations for their children and they are usually less engaged in their children's schooling (Looker & Thiessen, 2004). As chart 3.5 indicates, PCAP 2013 results show relatively small differences between provinces in terms of the mothers' level of education. In Canada overall, one in three mothers have a university degree, and only one in 20 did not complete high school. Unfortunately, about every fourth student does not know what level of education his/her mother has which is consistent with what the previous PCAP administrations reported. Analysis of science achievement shows a clear trend — having a mother with a higher level of education is associated with higher performance (chart 3.6). These results are consistent with the PCAP 2007 and 2010 data.

CHART 3.5 **Distribution of students by their mothers' education as reported by students**



[1] Some university education refers to having some higher education without having completed a degree.
[2] Some postsecondary education refers to any kind of education after high school.

CHART 3.6 **Relationship between mothers' education (as reported by students) and science achievement**



The number of books in the home is a factor related to socioeconomic status. As chart 3.7 shows, almost 20 per cent of Canadian students state that they have over 200 books in their home, but at the same time almost 30 per cent have fewer than 25 books in their home. Quebec stands out for having the fewest books in homes: only about one in eight students indicated that there are over 200 books in their home, whereas more than one in three students have fewer than 25 books at home. There is a lot of variation between the two language groups within jurisdictions as chart 3.8 shows. For example, 9 per cent more students in anglophone schools in Canada report that there are more than 200 books in their homes compared to students in francophone schools. Analysis of science scores indicates a clear positive relationship between the number of books in the home and student achievement (see chart 3.9). These results confirm data obtained in PCAP 2007 and 2010.

CHART 3.7 **Distribution of students by the number of books in their home by jurisdiction**

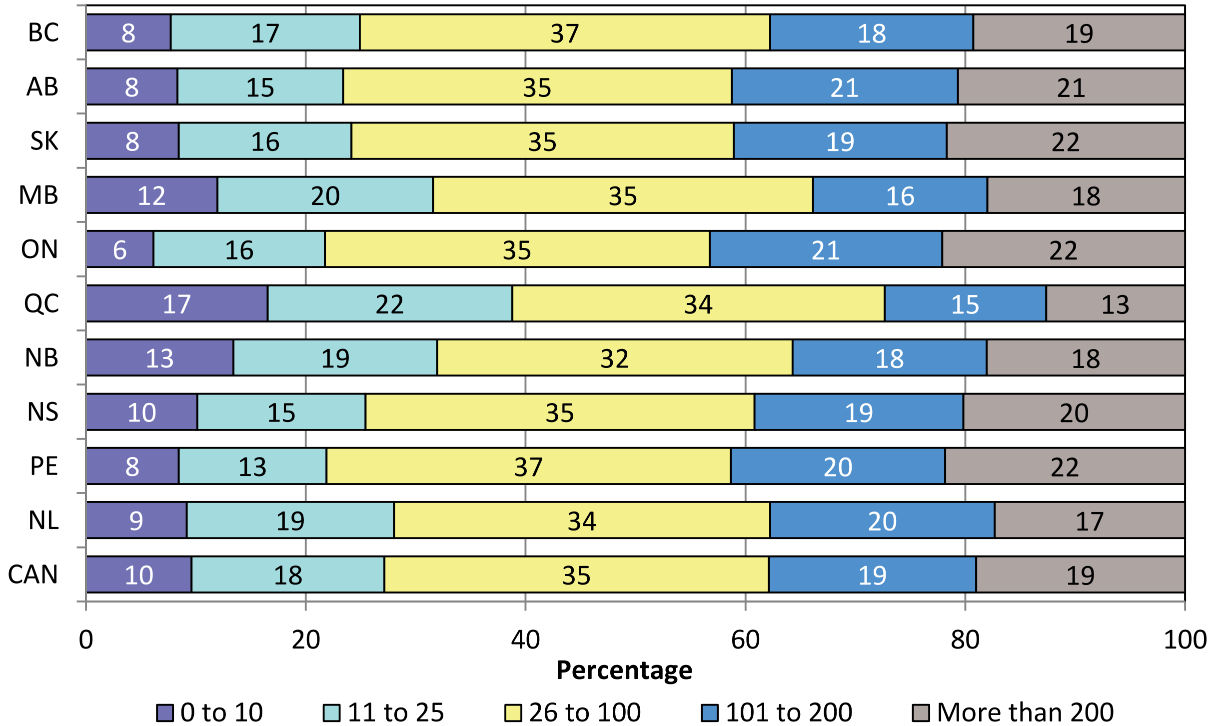


CHART 3.8 **Distribution of students by the number of books in their home by population**

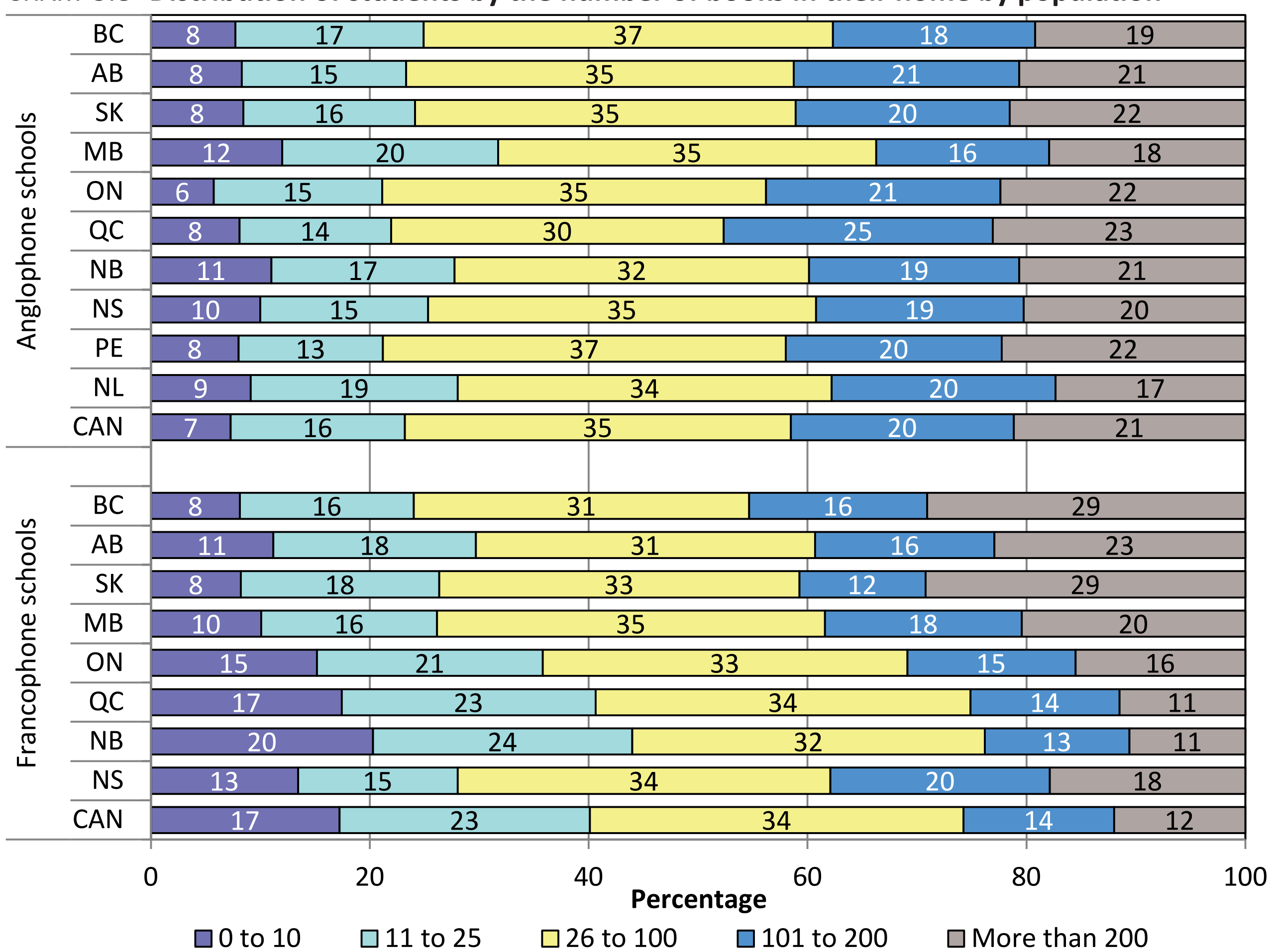
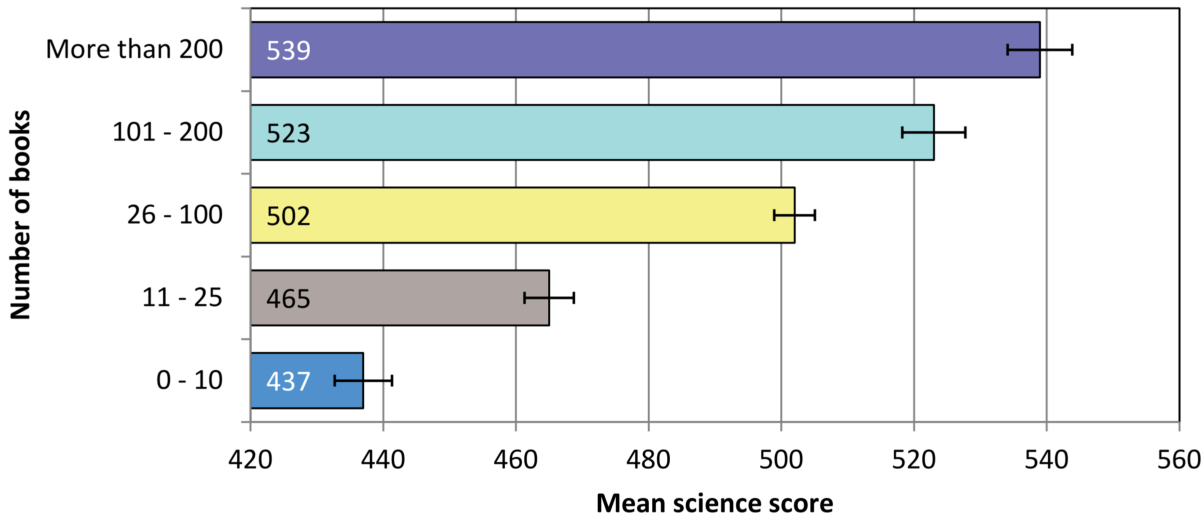


CHART 3.9 **Relationship between the number of books in the home and science achievement**

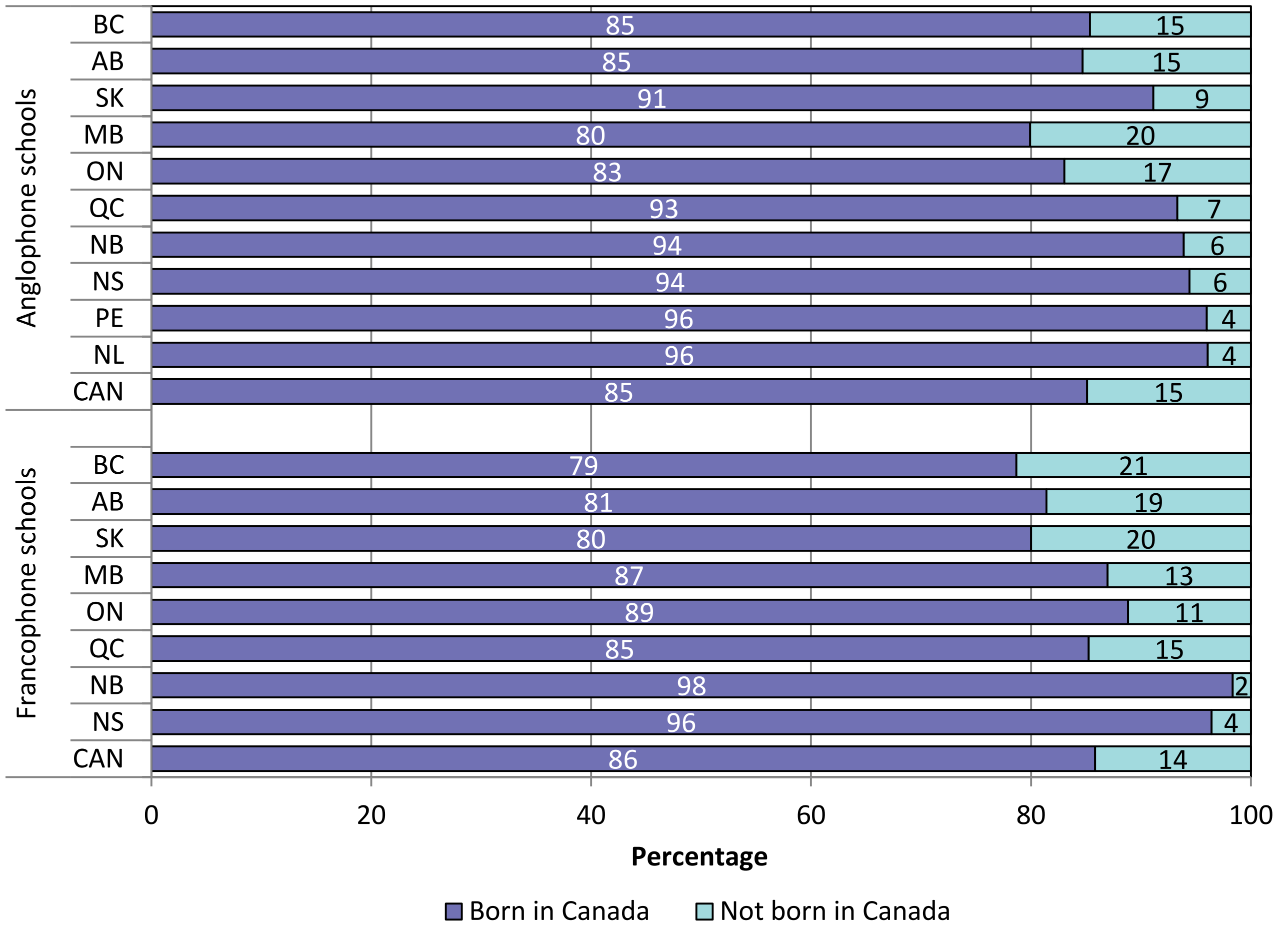


These data suggest that it is important for education policies to foster improvement in equity and performance by providing disadvantaged students with support that their parents might not be able to offer. Such support might include ensuring that all schools provide high-quality instruction and/or broadening social policies that could serve to minimize the differences in the life experiences inside and outside of school by mitigating the effects of socioeconomic factors on achievement.

Immigration status

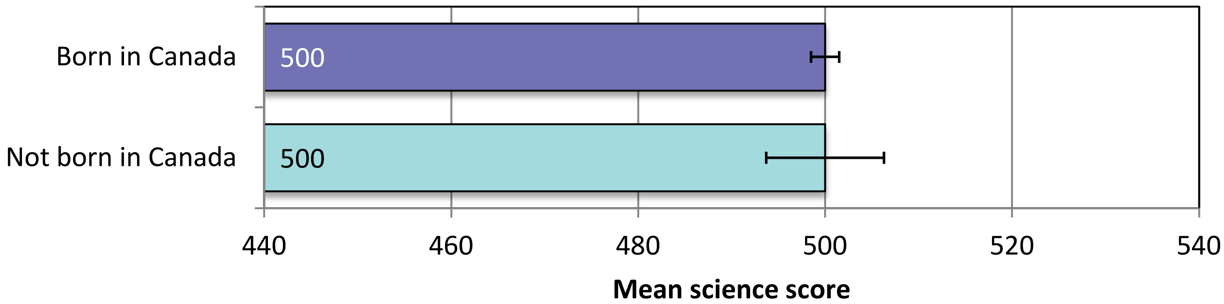
Canada welcomes over 250,000 immigrants each year of whom approximately 1.1 per cent are children (Citizenship and Immigration Canada, 2013). The proportion of Grade 8/Secondary II students born outside of Canada varies across the country. The smallest proportion of students who are not born in Canada (4 per cent or less) are in schools in Prince Edward Island, Newfoundland and Labrador, and francophone schools in Nova Scotia. The highest proportion (20 per cent or more) attend anglophone schools in Manitoba and francophone schools in British Columbia and Saskatchewan (chart 3.10).

CHART 3.10 **Distribution of students by immigration status**



Although the employment rate for immigrants is lower than that for those born in Canada, the difference diminishes with increasing levels of education (Statistics Canada, 2013b). Immigration status has no significant relationship with science achievement according to PCAP 2013 (chart 3.11). This differs from previous PCAP administrations that assessed mathematics and reading. In PCAP 2010, foreign-born students achieved higher mathematics scores than those born in Canada (CMEC, 2012). By contrast, in PCAP 2007, students born in Canada achieved higher reading scores than those born outside the country (CMEC, 2009). The relationship between immigration status and achievement in mathematics was examined using data from PISA 2012. No significant achievement gap for 15-year-olds was found (CMEC, 2015).

CHART 3.11 **Relationship between immigration status and science achievement**



Aboriginal identity

Students were asked about their Aboriginal identity in the PCAP 2013 student questionnaire. Geographically, as chart 3.12 shows, the largest proportion of Grade 8/Secondary II students that identify themselves as First Nations and Métis are found in Manitoba and Saskatchewan; Newfoundland and Labrador has the highest proportion of students who identify as Inuit. There are also significant differences between language groups within jurisdictions. For example, there are more than twice as many students who identify themselves as Métis in francophone schools compared to anglophone schools in Manitoba (see table 3.4). These data should not be interpreted as representing the Canadian population because only schools under provincial jurisdictions participated in this study — such students in federally operated schools are not included.

CHART 3.12 **Distribution of students by their Aboriginal identity by jurisdiction**

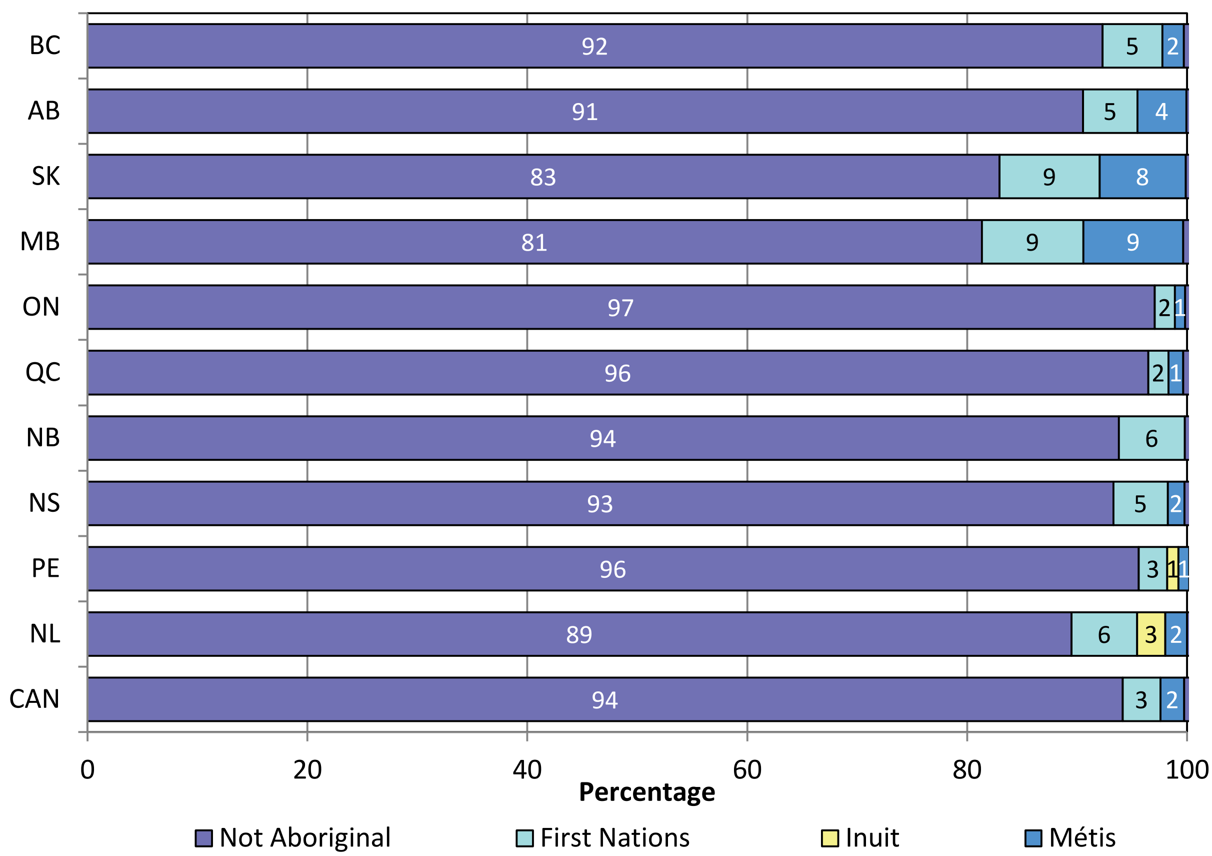
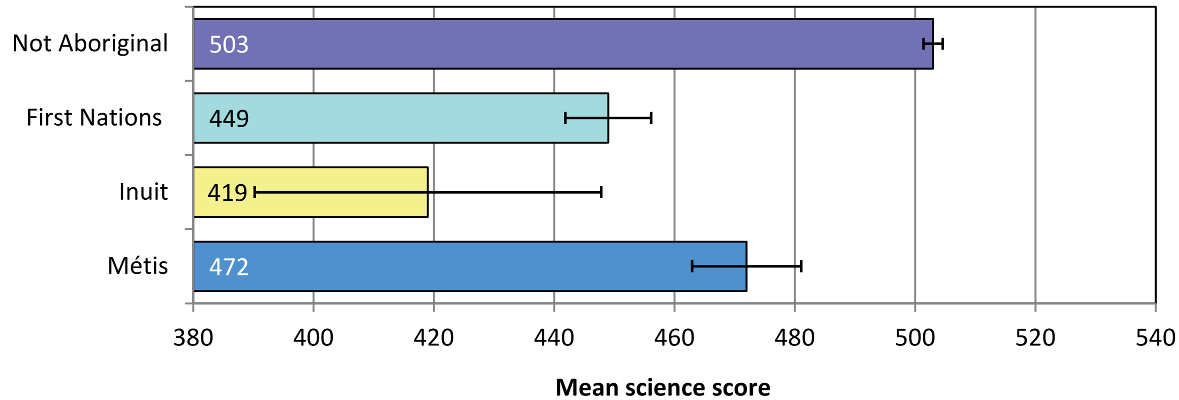


Table 3.4 Distribution of students by their Aboriginal identity by population

	Not Aboriginal	First Nations	Inuit	Métis
Anglophone schools				
BC	92.3	5.4	0.3	1.9
AB	90.5	4.9	0.1	4.5
SK	82.9	9.2	0.1	7.8
MB	81.3	9.4	0.4	8.9
ON	97.3	1.8	0.2	0.8
QC	94.5	4.1	0.4	1.1
NB	93.1	6.4	0.3	0.2
NS	93.3	5.0	0.2	1.5
PE	95.9	2.9	0.6	0.6
NL	89.5	5.9	2.6	2.0
CAN	**93.5**	**3.9**	**0.2**	**2.3**
Francophone schools				
BC	90.9	7.5	0.0	1.6
AB	95.1	3.1	0.0	1.8
SK	85.4	4.7	1.2	8.6
MB	81.9	0.8	0.0	17.2
ON	91.7	3.9	0.5	3.9
QC	96.7	1.6	0.4	1.4
NB	95.8	3.5	0.2	0.5
NS	93.0	2.2	1.4	3.4
CAN	**96.2**	**1.8**	**0.4**	**1.6**

As chart 3.13 shows, students who identify themselves as not an Aboriginal person achieve significantly higher science scores than those who identify themselves as Aboriginal. Students who identify themselves as Métis have significantly higher achievement than those who identify themselves as either First Nations or Inuit. Although success in school is often related to the tendency to pursue further education, the stronger achievement for students identifying themselves as Métis in PCAP 2013 is unfortunately not reflected in the proportion of students who continue their education beyond their years of mandatory schooling. As the National Household Survey (Statistics Canada, 2011a) reported, although 58 per cent of students who identify themselves as First Nations attain a postsecondary qualification, only approximately 35 per cent of students who identify as Inuit or Métis do so. The proportion of students who do not complete secondary school has been steadily declining in all provinces since the early 1990s. However, dropout rates remain higher for Aboriginal students (22.6 per cent) compared to non-Aboriginal students (8.5 per cent; Statistics Canada, 2011b).

CHART 3.13 **Relationship between students' Aboriginal identity and science achievement**



Summary

Chapter 3 presents the data on five student demographic and socioeconomic (SES) characteristics: gender, language, and student-reported status regarding SES, immigration, and Aboriginal identity. With respect to the school system's language, students whose first language is the same as the official language spoken by the majority of people in the jurisdiction achieve higher scores in science compared to those whose first language is the same as the official language spoken by the minority of the population. There is no significant difference in achievement between students indicating English or "other" as their first language. The two indicators of student socioeconomic status used in this study are mother's education and the number of books at home. As PCAP 2013 showed, having a mother with a higher level of education and having more books in the home are both associated with higher performance in science. Neither gender nor immigration status is shown to have a significant impact on science achievement.

Statistical note on factor analysis, index scores, and regression analysis

Factor analysis. To reduce the complexity of the analysis and to obtain more stable measures of attitudes, values, and learning experiences, some groups of questions are subjected to factor analysis. This technique is designed to determine if item responses cluster together in some psychologically meaningful way. If meaningful groupings can be found, factor analysis permits the construction of a smaller number of factors that are also called *indices*. For example, applying factor analysis to student attitudes toward science questions yielded a set of two indices, reduced from 11 individual questionnaire items. This illustrates the efficiency of this technique.

Index scores. An index score for each student on each factor is derived from the factor analysis, in much the same way as a scaled science score is derived from analyzing the science test items. Factor scores are typically computed in standard score form, with a mean of zero and a standard deviation of one. For convenience in presentation, and to avoid negative values on charts, the scores are transformed into a mean of 50 and a standard deviation of 10 for Canada as a whole. This is analogous to the transformation of science scores to a mean of 500 and a standard deviation of 100. However, the scale is deliberately different to avoid confusion of index scores with achievement scores. Mean index scores for groups such as jurisdictions should be examined in relation to the Canadian mean of 50 and standard deviation of 10. For example, a mean score of 52 for a group implies that the group is 0.20 standard deviation units above the mean for that index. It is important to stress that index scores should not be interpreted as percentages.

Quarters. In this report, the PCAP populations of interest are divided into four equal groups, or quarters, with regard to the value of the index under study. The mean score for each of these groups appears in the tables and charts.

Multiple regression analysis. Achievement is influenced by a large number of factors that may act independently or in combination to affect the outcome. For example, previous results indicate that both mothers' education and the number of books in the home influence science achievement. However, these two factors themselves are correlated. If taken together, one may be more prominent than the other or one may have no effect on achievement once the other is accounted for.

In survey research, the standard statistical technique for isolating effects is known as multiple regression analysis or regression modelling. This technique is based on an equation in which the outcome (or dependent variable) is seen as a linear combination of a series of factors (predictors or independent variables). The contribution of any one predictor to the outcome is represented by a regression coefficient, the value of which depends on the effect of the predictor itself and of the other variables in the model. The relative sizes of the regression coefficients in a particular model may be used to indicate the relative contributions of the factors of interest. Models that include or exclude a particular variable may also be used to identify the unique contribution of that variable while controlling for others.

When it can be assumed that the sample units are selected by simple random sampling the ordinary least square (OLS) method of estimation yields unbiased statistics. On the one hand, applying the OLS method to a complex design sample (e.g., clustered sample) can result in misleading statistical inference. To avoid such a bias, the data can be analyzed either from the design standpoint or from a modelling perspective. The design standpoint seeks to obtain statistics with a high degree of precision by taking into account the sampling design. From the modelling standpoint, a hierarchical or multilevel model would be fitted to the data with the goal of partitioning the residuals' variance into the higher-level component (e.g., between-school variation) and the lower-level component (e.g., within-school component or variation among students). The statistics reported in the following chapters result from a design-based or survey-based linear regression modelling. Multilevel analysis will be carried out and the results published in forthcoming reports. This report discusses only variables that show statistically significant relationships ($p < 0.05$) with science achievement.

A number of questions to students were designed to obtain data on their attitudes toward school, science, and learning. As the statistical note explained, these questions were subjected to a set of factor analysis that allowed researchers to identify items that are related to a single construct. As a result of this technique, a total of 24 factors (also called indices) were identified. Each index was constructed so that the average score across Canada is 50 and so that two-thirds of the population are between 40 and 60 (i.e., a standard deviation of 10). Highly correlated indices were combined to simplify analysis and reporting of results.

This chapter examines the relationship between student indices and science performance through (1) multiple regression analysis, and (2) the difference in average science scores between the top quarter and bottom quarter on the indices. The attitude indices are based on students' perceptions of the construct being measured.

Multiple regression model: Student indices that significantly affect science achievement

Analysis to identify the correlation between student indices and science scores was performed to determine the list of variables to be entered into a multiple regression model. While most of the indices showed a significant relationship with science performance, only the indices with a correlation coefficient equal to or above .20 were kept for a regression analysis. The selected indices are:

- attitude toward science
- science self-efficacy
- experience with science in early years
- value of science to the goals of the student and to society
- understanding what science is and how it is done

- attribution of success or failure to others' action (tendency to fatalism)
- teacher-directed lessons.

These indices were entered as predictors into a multiple regression model, while controlling for the following variables: first language, Aboriginal identity, number of books at home, mother's education, homework frequency in all school subjects, and homework frequency in science. The model explained 25 per cent of variation in student science performance ($R^2 = .25$).

Almost all of the effects are significantly attenuated in the multiple regression model relative to those in the simple regression model, though most remain statistically greater than zero. For one index called teacher-directed and student-centred lessons, the direction of the factor's effects for teacher-directed lessons is reversed in the multiple regression model. This indicates that the effect for any one variable is related in some way to the effects of the other variables in the model.

In total, five student indices show positive relationships with science performance (i.e., attitude toward science, science self-efficacy, experience with science in the early years, value of science, and understanding of science), while one index shows a negative relationship (i.e., tendency to fatalism).

Data for other student indices with correlation coefficients less than .2 were not included in the regression model. These indices include:

- attitude toward school
- bullying
- general interest in science
- perseverance and seeking help when encountering difficulty understanding science
- learning through student-centred lessons
- frequency of science-related activities or discussions in the classroom
- frequency of out-of-school activities
- participation in out-of-class, science-related activities.

Attitude toward science

Description of the index

Students' attitude toward science has been a topic of great interest for many years, in part because advanced societies look to science and technology to sustain their economic lead. There is general agreement that attitudinal constructs are associated with student achievement, although this relationship has been a matter of debate with different studies reporting mixed results (Tytler & Osborne, 2012).

The "attitude toward science" index is based on students' degree of agreement, using a four-point scale from strongly disagree to strongly agree, with 11 statements, as shown in Table 4.1.[19] This index

[19] Exploratory factor analysis of this series of items initially yielded two factors. However, because these two factors were highly correlated, a decision was made to combine them into one factor for regression analysis.

measures students' perception of their ability to learn science as well as general attitudes toward science.

TABLE 4.1 **Questionnaire items for the "attitude towards science" index**

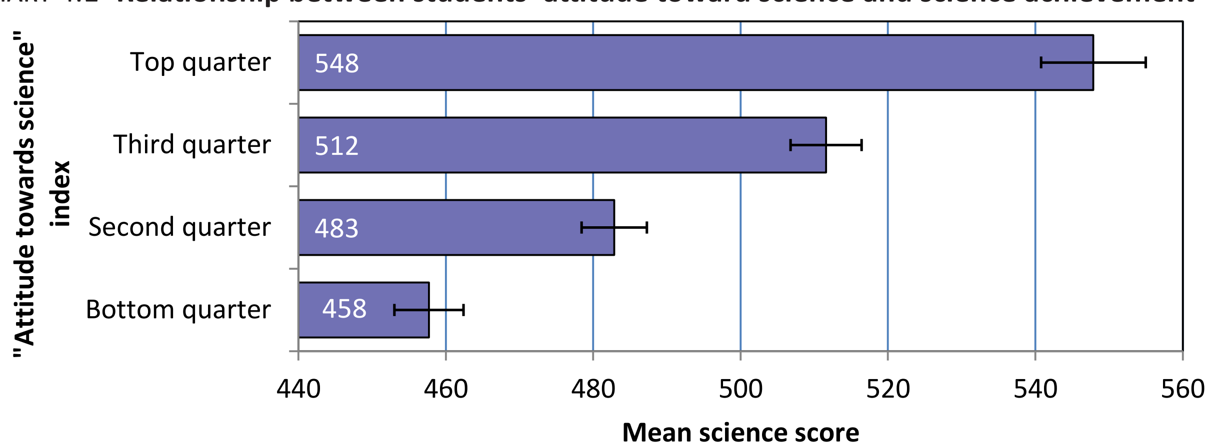
Describe how much you agree or disagree with each of the following statements.
Learning science is easy for me.
I can usually give good answers to science test questions.
I learn science concepts quickly.
I understand most of the science I am taught.
I feel nervous when doing a science activity.
Learning science is a waste of time.
Making an effort in science class is worth it because I would like this type of job later on.
I like hands-on science activities.
Science is boring.
I enjoy learning new information in science.
I like reading about science.

Relationship of the index with science achievement

For Canada overall, four groups of students were identified according to the extent to which they agree with the "attitude" items (bottom quarter, second quarter, third quarter, and top quarter). The top quarter represents students who tend to have positive beliefs in their science-related abilities as well as a positive attitude toward science in general, while the bottom quarter represents students who tend to have negative attitudes and beliefs.

Chart 4.1 shows the relationship between the "attitude towards science" index and science achievement. In this case, there is a general pattern of increased science performance with increasingly positive attitudes and beliefs. The score difference between students in the top and the bottom quarters of this index is 90 points.

CHART 4.1 **Relationship between students' attitude toward science and science achievement**

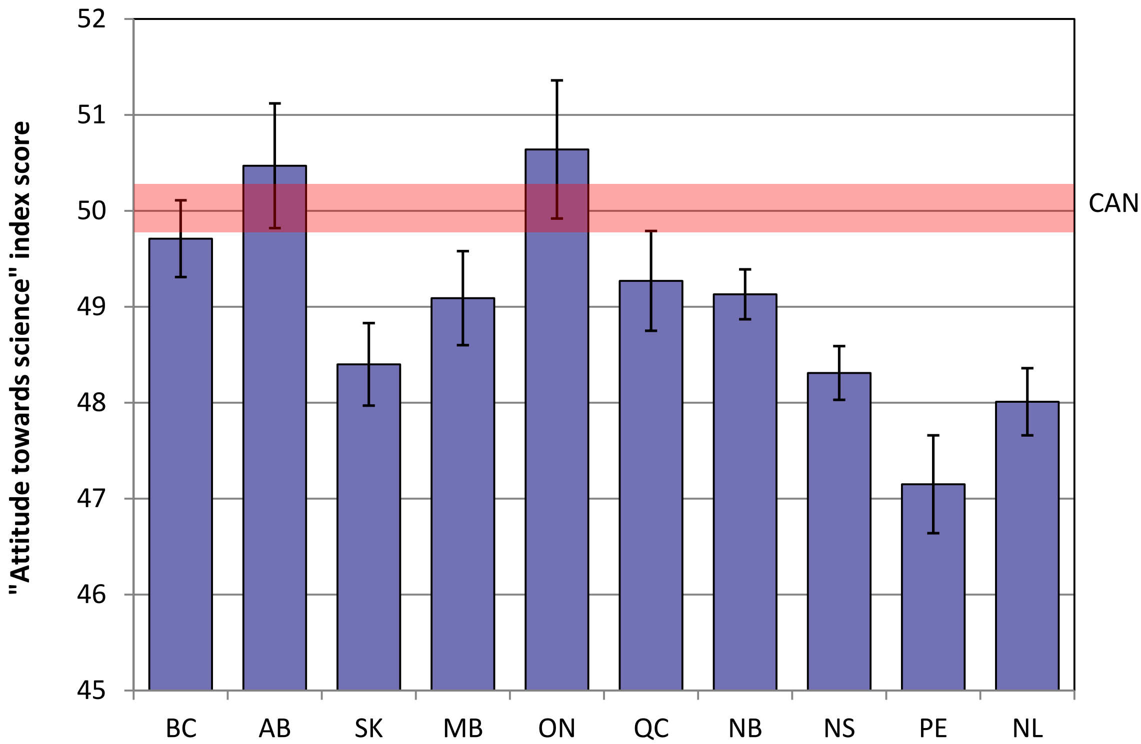


The relationship between positive attitudes and science achievement has been reported in other studies. This relationship between attitude and achievement was found for both Grade 4 and Grade 8 students in TIMSS 2011 (Martin et al., 2012) although the proportion of students with positive attitudes decreased with older students.

Results by province

Since the "attitude toward science index" is a significant predictor of science performance, it is important to examine it by province. As chart 4.2 shows, the overall result for Canada is 50 ± 0.33. Students in British Columbia, Alberta, Ontario, and Quebec are similar to the Canadian average — they report a more positive attitude toward science and greater confidence in their ability to do science. Students in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador demonstrated less positive attitudes and beliefs.

CHART 4.2 **Average index scores by province: "Attitude towards science"**



Science self-concept, as the PISA survey reported for 15-year-olds, showed scores on this index to be relatively similar across most of Canada though students in Manitoba and Saskatchewan reported lower confidence in their ability to do science (Bussière et al., 2007).

Results by language

Scores on the "attitude towards science" index are also examined by language. The results appear in table 4.2. Most jurisdictions show no significant difference between the two language systems on the attitude towards science index. More positive student attitudes toward science and more confidence in their ability to learn science are found in English-language schools in Canada overall and in French-language schools in British Columbia and New Brunswick.

Table 4.2 **Average index scores by language: "Attitude towards science"**[20]

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	49.8	0.4	52.9	1.6	3.1*
AB	50.5	0.7	49.2	1.6	1.3
SK	48.4	0.4	49.8	1.9	1.4
MB	49.1	0.5	50.8	1.7	1.7
ON	50.8	0.7	49.6	0.8	1.2
QC	49.5	0.8	49.4	0.6	0.1
NB	49.1	0.3	50.2	0.3	1.0*
NS	48.4	0.3	47.9	1.0	0.4
PE	47.2	0.5	--	--	--
NL	48.1	0.4	--	--	--
CAN	**50.0**	**0.4**	**49.0**	**0.5**	**1.0***

* denotes significant difference

Table 4.3 presents the comparisons to the Canadian mean for each of the two language systems for the "attitude towards science" index. In the English-language school system, students in British Columbia, Alberta, Ontario, and Quebec report positive attitudes toward science and confidence in their abilities in science that are similar to Canadian English-language students overall. Students in English-language schools in other jurisdictions are found to be less positive in their attitudes and less confident in their abilities to learn science than their Canadian English counterparts. In the French-language school system, students in British Columbia and New Brunswick report more positive attitudes and greater confidence in science than students in Canadian French schools overall. French-speaking students in Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia show attitudes and self-beliefs similar to the Canadian French average.

Table 4.3 **Provincial results in relation to the Canadian average by language: "Attitude towards science" index**

	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
		British Columbia, Alberta, Ontario, Quebec	Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador
Francophone schools			
	British Columbia, New Brunswick	Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia	

[20] Owing to the small sample size, results for students enrolled in French-language schools in Prince Edward Island and Newfoundland and Labrador are not indicated in these results; however, they are included in the calculations for the overall mean science and index scores in those jurisdictions.

Science self-efficacy

Description of the index

Self-efficacy beliefs refer to one's confidence in engaging in specific activities that contribute to progress toward one's goals (Bandura, 1977). Science self-efficacy measures students' confidence to perform science-related tasks. The belief in their ability to succeed in science is an important outcome of education and highly relevant to students' successful learning. A strong sense of self-efficacy can affect students' willingness to take on challenging tasks and to make an effort and persist in tackling such tasks: it can thus have a key impact on motivation (Bandura, 1997). To assess self-efficacy in PCAP 2013, students were asked to rate the ease with which they believed they could perform the 12 science tasks listed in table 4.4. Students used a four-point rating scale that ranged from "I could not do this" to "I could do this easily."

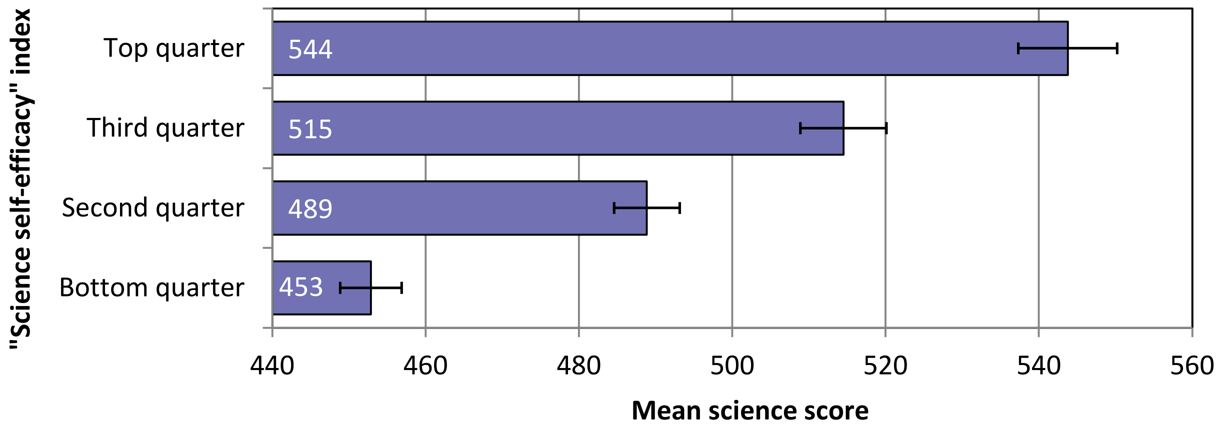
TABLE 4.4 **Questionnaire items for the "science self-efficacy" index**

How easy would it be for you to perform the following tasks on your own?
Suggest a meaningful question that could be answered with an experiment.
Design a procedure that could be used to answer a science question.
Make good observations during an experiment.
Be sure that data collected during an experiment is accurate.
Be able to recognize a pattern or relationship in data you have collected.
Suggest a possible explanation for a pattern or relationship you have observed in an experiment.
Use the result of an experiment to solve a problem in your daily life (e.g., at home, during sports).
Recognize the assumptions you need to make to solve a problem or reach a conclusion.
Use scientific thinking to make a decision in your daily life.
Use scientific ideas to explain and support your ideas on a topic that is important to you (e.g., related to the environment or to health care).
Decide whether someone has given good reasons to explain their point of view about a science topic.
After listening to two different scientific explanations on the same issue, choose the one you think you would trust.

Relationship of the index with science achievement

Chart 4.3 shows the relationship between science achievement and the "science self-efficacy" index. Students are grouped into four quarters based on their score on this index. The bottom quarter of the index represents less confidence with science-related tasks and the top quarter represents greater confidence. The results show that students with the highest level of self-efficacy (i.e., those in the top quarter of the index) have significantly higher average scores in science. The score difference for students in the top and the bottom quarters of this index is 91 points.

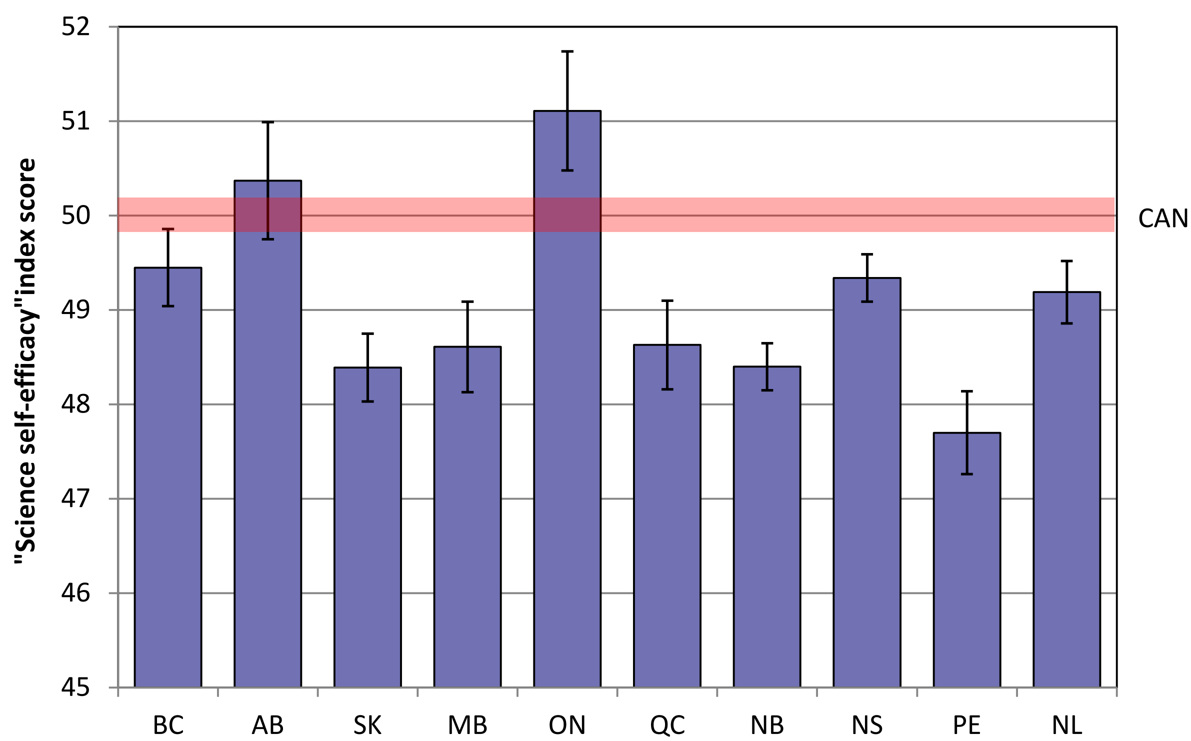
CHART 4.3 **Relationship between students' science self-efficacy and science achievement**



Results by province

Given the importance of the "science self-efficacy" factor for student performance, the results will now be examined by province. Ontario students report the highest levels of confidence in performing science-related tasks (science self-efficacy), while British Columbia and Alberta students report similar levels of self-efficacy compared to Canadian Grade 8/Secondary II students as a whole. Students in Saskatchewan, Manitoba, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador demonstrate lower levels of confidence in their science aptitude than the Canadian average (50 ± 0.29), as shown in chart 4.4.

CHART 4.4 **Average index scores by province: "Science self-efficacy"**



Results by language

Scores on the "self-efficacy" index are examined by language; the results appear in table 4.5. Only three provinces show significant differences between English- and French-language schools systems. In Ontario, anglophone students report a higher level of confidence in their ability to do science than their francophone counterparts. In British Columbia and New Brunswick the opposite is true — higher levels of confidence are reported by francophone students. In Canada overall, students in the English-language school system demonstrate higher levels of science self-efficacy than those in the French-language school system.

Table 4.5 **Index scores by language: "Science self-efficacy"**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	49.6	0.4	51.3	1.0	1.8*
AB	50.4	0.6	50.3	1.7	0.1
SK	48.4	0.4	48.4	1.4	0.0
MB	48.7	0.5	49.9	1.3	1.2
ON	51.3	0.6	49.2	0.8	2.2*
QC	49.8	0.7	48.6	0.5	1.2
NB	48.3	0.3	49.7	0.4	1.4*
NS	49.4	0.3	48.7	0.8	0.7
PE	47.7	0.4	--	--	--
NL	49.3	0.3	--	--	--
CAN	**50.0**	**0.4**	**49.0**	**0.5**	**1.0***

* denotes significant difference

Student scores for the "science self-efficacy" index are also compared to the Canadian mean for each language group (table 4.6). In the English-language school system, students in Ontario report the highest level of confidence to perform science-related tasks and students in Saskatchewan, Manitoba, New Brunswick, Prince Edward Island, and Newfoundland and Labrador report the lowest confidence. Anglophone sections of British Columbia, Alberta, Quebec, and Nova Scotia show results similar to the Canadian English average. In the French-language school system, the highest level of science self-efficacy is found in British Columbia, while other jurisdictions demonstrate the same level of self-efficacy as the Canadian French average.

Table 4.6 **Provincial results in relation to the Canadian average by language: "Science self-efficacy" index**

	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
	Ontario	British Columbia, Alberta, Quebec, Nova Scotia	Saskatchewan, Manitoba, New Brunswick, Prince Edward Island, Newfoundland and Labrador
Francophone schools			
	British Columbia	Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia	

Experience with science in early years

Description of the index

We often talk about children as "natural scientists" and of their natural inclination to "spontaneously wonder" about things. Young children develop fundamental understandings of observed phenomena in their natural world and essential science process skills during their earliest years (Eshach & Fried, 2005; Gallenstein, 2003). These basic science understandings and skills begin to develop as early as infancy, and children's competency becomes more sophisticated as they develop (Kuhn, et al., 1988; Kuhn & Pearsall, 2000; Piaget & Inhelder, 2000).

Students participating in PCAP 2013 were asked about their experience with science, both recently and when they were younger. To clarify the question, some of the examples used in these items came from students' written responses to questions in the field test about their science experiences. Exploratory analysis revealed that although recent experiences with science are not strongly correlated with science achievement, experiences when students were younger did have a significant impact on success in science in this study. The index for early years' experience with science measures the extent to which the students participated in science-related activities when they were younger. Table 4.7 presents the series of questionnaire items used to explore these experiences.

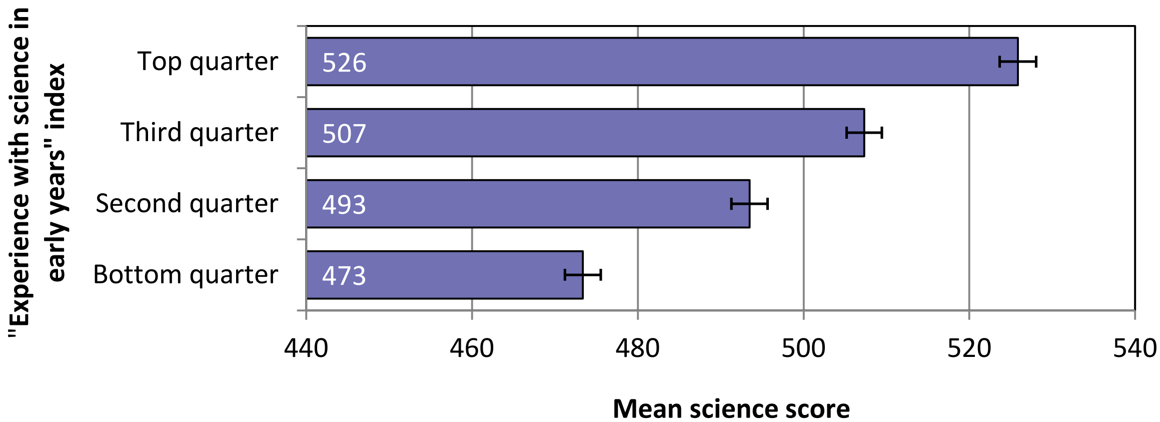
Table 4.7 **Questionnaire items for the "experience with science in early years" index**

Which of the following statements apply to your experiences when you were younger?
I tried to figure out mechanical devices (e.g., bicycle, wheelbarrow, sewing machine).
I tried to figure out electrical devices (e.g., batteries, light bulbs, radio, computer).
I observed animals (e.g., bird making a nest, ant farm).
I took care of a pet or farm animal.
I observed or studied stars or other objects in the sky.
I planted seeds or watched plants grow.
I read science books.

Relationship of the index with science achievement

To examine the relationship of the early years experience in science and student performance, students were grouped into four quarters. The top quarter for this index represents students with richer science experiences in their early years, while the bottom quarter represents students with poorer science experiences. As chart 4.5 indicates, there is a clear pattern of higher achievement with increasing involvement in science-related activities at a younger age. Students in the top quarter of this index score 53 points higher on the science scale than their counterparts who scored in the bottom quarter.

CHART 4.5 **Relationship between experience with science in early years and science achievement**

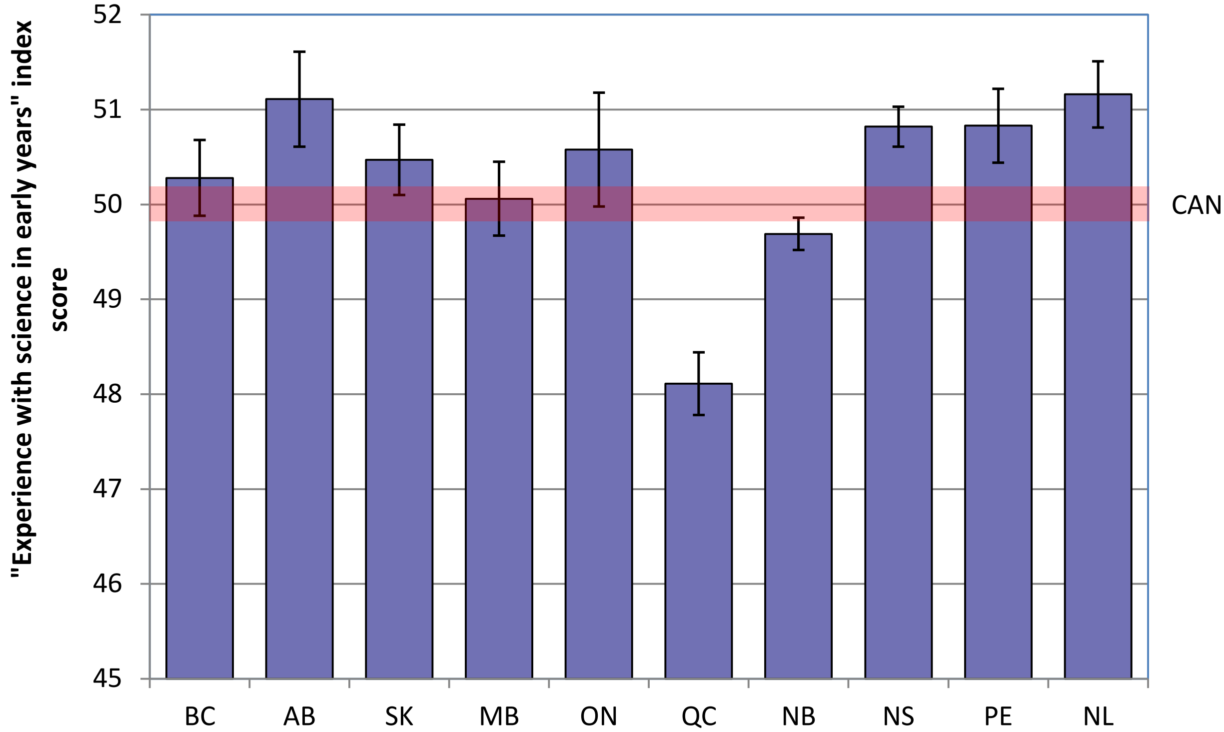


This is consistent with findings from other national and international surveys for a variety of subjects. Students who reported that their parents helped them to learn to read achieved higher scores (CMEC, 2009) as did students who participated in mathematics-related play and informal learning activites (CMEC, 2012). PIRLS data show that Canadian parents report higher rates of involvement in their children's early-literacy and numeracy activities than parents in other countries do, with at least half of Canadian families engaging in these activities often (Labrecque et al., 2012).

Results by province

As chart 4.6 presents, all jurisdictions except Quebec are at or above the Canadian average (50 ± 0.27) for the index of early years science experience. This is consistent with the results from the surveys of parents of Grade 4 students in PIRLS 2011 (Labrecque et al., 2012) and that of Grade 8 students in TIMSS 2011 (Mullis et al., 2012a).

CHART 4.6 **Average index scores by province: "Experience with science in early years"**



Results by language

There is a significant difference within most provinces for the "experience with science in early years" index between the English- and French-language school systems (see table 4.8). Grade 8/Secondary II students in English-language schools in Alberta, Saskatchewan, Ontario, Quebec, New Brunswick, and Nova Scotia report high levels of participation in science-related activities. By contrast, in British Columbia students in French-language schools report more participation in science activities when they were young. There is no significant difference between the two language systems in Manitoba and New Brunswick.

TABLE 4.8 **Average index scores by language: "Experience with science in early years"**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	50.3	0.4	52.3	1.1	2.1*
AB	51.1	0.5	49.5	0.9	1.7*
SK	50.5	0.4	47.3	1.7	3.2*
MB	50.1	0.6	50.1	0.7	0.1
ON	50.6	0.5	49.1	0.4	1.6*
QC	49.8	0.2	47.9	0.4	1.8*
NB	49.9	0.2	49.2	0.6	0.7
NS	50.9	0.4	49.4	1.0	1.5*
PE	50.8	0.4	--	--	--
NL	51.2	0.4	--	--	--
CAN	**51.0**	**0.3**	**48.0**	**0.3**	**3.0***

* denotes significant difference

Compared to the Canadian means for the two language systems, students in francophone schools in British Columbia, Manitoba, Ontario, New Brunswick, and Nova Scotia are above the Canadian French mean on this index. All other populations have scores similar to or below the Canadian English- and French-language means for the index for early years' experience with science (see table 4.9).

TABLE 4.9 **Provincial results in relation to the Canadian average by language: "Experience with science in early years"**

	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
		British Columbia, Alberta, Saskatchewan, Ontario, Nova Scotia, Prince Edward Island, Newfoundland and Labrador	Manitoba, Quebec, New Brunswick
Francophone schools			
	British Columbia, Manitoba, Ontario, New Brunswick, Nova Scotia	Alberta, Saskatchewan, Quebec	

Students' value of science

Description of the index

How students value science reflects their level of appreciation of it as being important to society at large and their belief that science is relevant and useful in their own lives. Based on student responses to the series of questions in table 4.10, the "value of science" index was constructed.[21]

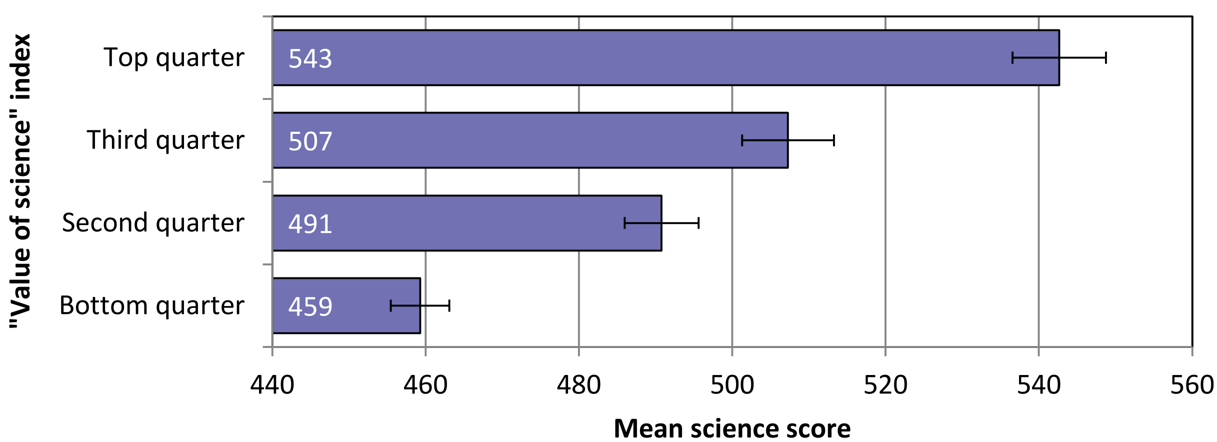
TABLE 4.10 **Questionnaire items for the "value of science" index**

Describe how much you agree or disagree with each of the following statements.
I will use science in many ways when I am an adult.
Science and technology are relevant to me.
I recognize where science is found in my daily life (e.g., newspaper articles, food labels).
I find that science helps me to understand how things work.
Science helps me understand the things around me in my daily life.
Advances in science and technology make our lives healthier, easier, and more comfortable.
Science is valuable to society.
Science is more beneficial than harmful.
Science and technology can help eliminate poverty and famine in the world.

Relationship of the index with science achievement

There is a relationship between students' value of science and their science performance as chart 4.7 shows. Grade 8/Secondary II students in the top quarter of this index scored 84 points higher on the science scale than their counterparts who scored in the bottom quarter of this index.

CHART 4.7 **Relationship between students' value of science and science achievement**



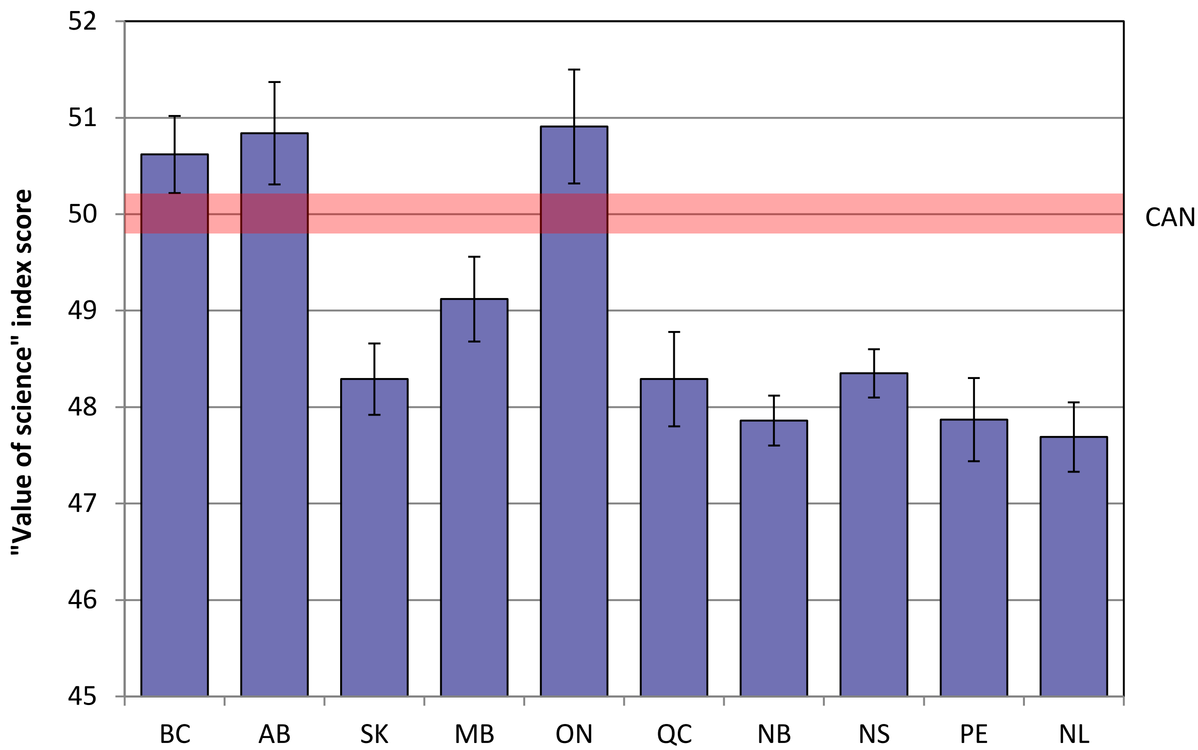
[21] Exploratory factor analysis of this series of items initially yielded two factors (one related to the individual value of science and another to the societal value of science). However, because there was a high correlation between these two factors, they were combined into one factor for regression analysis.

Research shows that students' attitude toward science and the value that they place on it declines as they progress through school (George, 2007; Jenkins & Nelson, 2005). Barmby, Kind, and Jones (2008) identified that the sharpest decline in students' attitudes toward learning science occurred while they were still in school. Although this decline influences attitudes toward future participation in science, it may not be a good indicator of the value that a student places on the personal and society influences of science. Although a student may not be interested in pursuing science, they may still value aspects of it, such as using evidence to make decisions, in their daily lives.

Results by province

Students in British Columbia, Alberta, and Ontario report the highest value of science for their lives and society. All other provinces are below the Canadian average (50 ± 0.29).

CHART 4.8 **Average index scores by province: "Value of science"**



PISA 2006 identified that, compared to 15-year-olds internationally, Canadian youth believe more strongly that science is important and valuable to society at large as well as for their own purpose (Bussière et al., 2007).

Results by language

In Canada overall, students in anglophone schools report that they place a higher value on science than those in francophone schools. Within provinces, there are few significant differences between English- and French-language schools on the "value of science" index. Students enrolled in French-language schools in British Columbia and New Brunswick attribute a greater importance to science both to themselves and society (see table 4.11). Students in francophone schools in British Columbia, Ontario, Quebec, and New Brunswick were the only groups to score higher than the Canadian average on this index (see table 4.12).

TABLE 4.11 **Average index scores and differences by language: "Value of science"**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	49.8	0.4	52.9	1.4	3.1*
AB	50.5	0.5	49.2	1.3	1.3
SK	48.4	0.4	49.8	1.8	1.4
MB	49.1	0.4	50.8	1.5	1.7
ON	50.8	0.6	49.6	0.8	1.2
QC	49.5	0.9	49.4	0.5	0.1
NB	49.1	0.3	50.2	0.4	1.0*
NS	48.4	0.3	47.9	0.9	0.4
PE	47.2	0.4	--	--	--
NL	48.1	0.4	--	--	--
CAN	**50.0**	**0.3**	**48.0**	**0.5**	**2.0***

* denotes significant difference

TABLE 4.12 **Provincial results in relation to the Canadian average by language: "Value of science"**

	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
		British Columbia, Alberta, Ontario, Quebec	Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador
Francophone schools			
	British Columbia, Ontario, Quebec, New Brunswick	Alberta, Saskatchewan, Manitoba, Nova Scotia	

Understanding of science

Description of the index

By emphasizing not only the empirical nature of science but also the underlying heuristic principles, science education can facilitate conceptual understanding (Niaz, 2001). Given that a goal of provincial science curricula is to foster the development of scientifically literate citizens, it is important for students to develop a broader understanding of what science is and how scientists contribute to the impartial development of knowledge. The data related to this issue may also contribute to the broader issues surrounding the idea of publicly engaged science.

The understanding-of-science index was constructed using the degree of agreement that students reported to a series of items exploring their understanding of how science is done and what science is (see table 4.13).[22]

Table 4.13 **Questionnaire items for understanding-of-science factors**

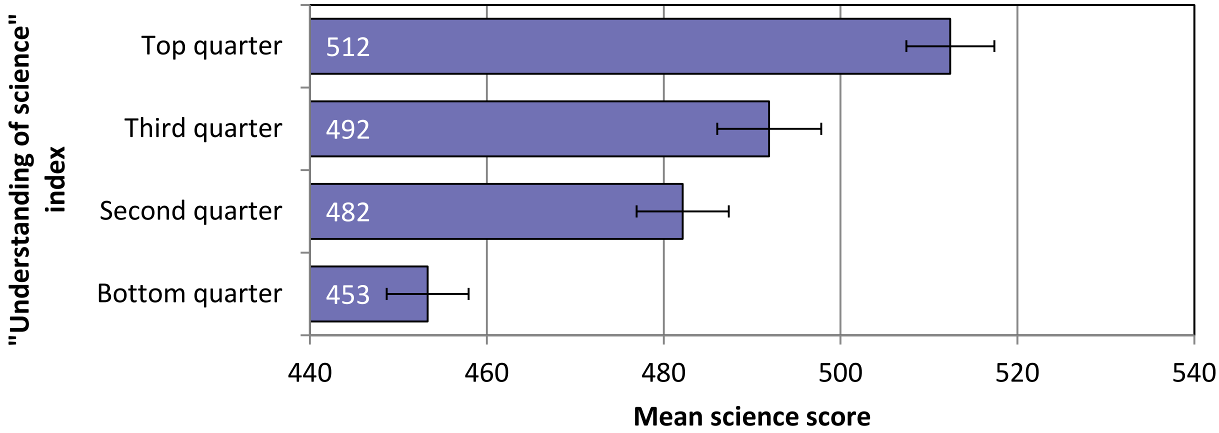
Describe how much you agree or disagree with each of the following statements.
Scientists should be able to repeat other scientists' experiments.
Explanations in science should be based on evidence.
In science, observations and experiments are used to gather data about the world.
Sometimes there is not enough evidence to draw a conclusion.
New knowledge must be explained by starting with what we already know.
Scientific knowledge can change when new information is obtained.
There is a difference between scientific knowledge and personal opinion.
Science is a collection of facts.
Science is creative.
Science is impartial and fair.
Science can answer all questions.
Scientific results can be trusted.
Scientists who follow the scientific method will get the correct answer.

Relationship of the index with science achievement

There is a 59-point difference in science achievement scores between students in the top and bottom quarter for this index (see chart 4.9). This is not surprising given that higher levels of knowledge about the processes of science and a greater appreciation for science as a trusted vehicle of knowledge production could be motivating factors for students learning science in school.

22 Exploratory factor analysis of this series of items initially yielded two factors (one related to how science is done and another to what science is). However, the high correlation between these two factors led to them being combined in the final analysis for this index.

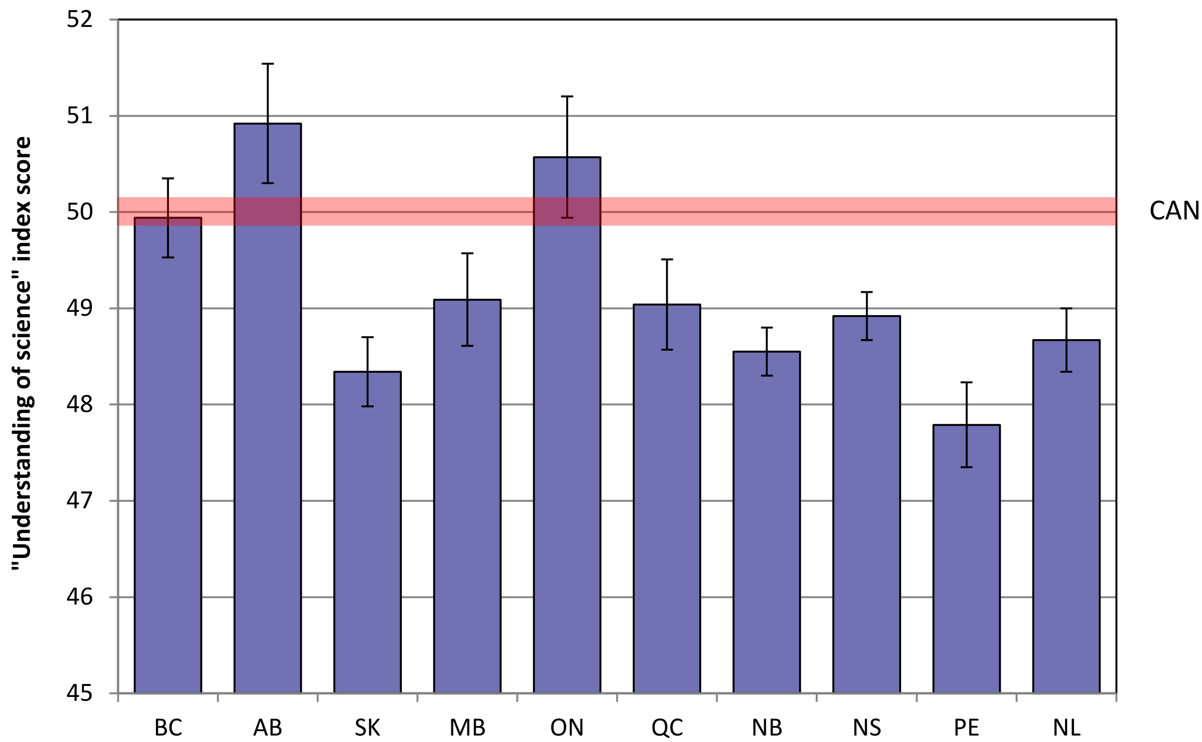
CHART 4.9 **Relationship between students' understanding of science and science achievement**



Results by province

Students' reported level of understanding science varied between provinces. The highest scores on this index are found in British Columbia, Alberta, and Ontario. All other provinces score below the Canadian average (50 ± 0.24) on the "understanding of science" index (see chart 4.10).

CHART 4.10 **Average index scores by province: "Understanding of science"**



Results by language

In Canada overall, anglophone school systems show significantly higher understanding of science than francophone school systems. At the provincial level, there are few differences between English- and

French-language schools for this index. Significant differences in the scores are found only in Ontario and Nova Scotia with students in English-language schools in both provinces reporting higher levels of understanding of science than their counterparts in French-language schools (table 4.14).

TABLE 4.14 **Average index scores by language: "Understanding of science"**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	50.7	0.3	51.7	1.5	0.9
AB	50.9	0.6	49.2	1.5	1.8
SK	48.3	0.4	48.5	2.9	0.1
MB	49.2	0.5	48.6	1.4	0.6
ON	51.1	0.5	48.3	0.7	2.8*
QC	49.5	0.7	48.3	0.5	1.2
NB	48.2	0.3	47.8	0.4	0.4
NS	48.4	0.3	46.9	1.3	1.6*
PE	47.9	0.4	--	--	--
NL	47.8	0.4	--	--	--
CAN	**50.0**	**0.3**	**49.0**	**0.5**	**1.0***

* denotes significant difference

When compared to the Canadian means for the two language systems on this index, the highest levels of understanding science are reported by English-language students in British Columbia and Ontario and by French-language students in British Columbia (see table 4.15).

TABLE 4.15 **Provincial results in relation to the Canadian average by language: "Understanding of science" index**

	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
	British Columbia, Ontario	Alberta, Manitoba, Quebec	Saskatchewan, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador
Francophone schools			
	British Columbia	Alberta, Saskatchewan, Manitoba, Ontario, Quebec	New Brunswick, Nova Scotia

Tendency to fatalism

Description of the index

Fatalism can be conceptualized as a set of beliefs that encompasses such dimensions as predestination, pessimism, and attribution of one's life events to luck (Shen & Condit, 2013). Fatalism has been associated with motivation and self-regulated learning (de Bilde, Vansteenkiste, & Lens, 2011) as well as academic attitudes and achievement (Guzmán, Santiago-Rivera, & Hasse, 2005). However, the overwhelming majority of research on fatalism has been in health contexts. Despite the range in ways to define fatalism, scholars tend to agree that fatalism is cognitive in nature.

To explore the relationship between fatalism and student achievement in science, students were asked a series of questions on a four-point Likert-type scale (from strongly disagree to strongly agree) that had to do with their attributions of success or failure in their science school work. The "tendency to fatalism" index was constructed based on three items (table 4.16).

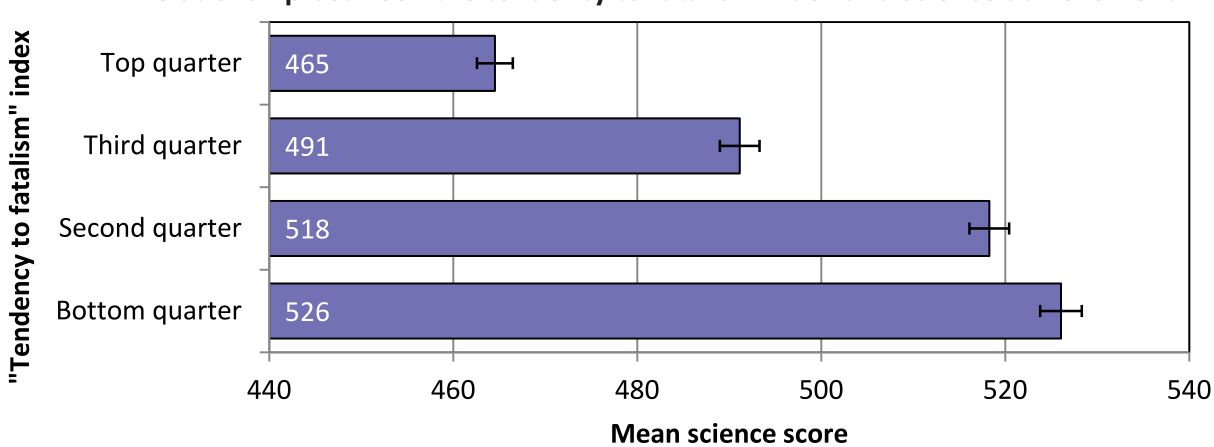
TABLE 4.16 **Questionnaire items for the "tendency to fatalism" index**

If I do well in science, it is because of ...
natural ability.
If I do poorly in science, it is because of ...
not enough natural ability.
bad luck.

Relationship of the index with science achievement

Students who score high on this index have a higher tendency to fatalism — that is, they believe their poor achievement is the result of a lack of natural ability or bad luck. Students with low scores believe that their good performance is caused by natural ability. The "tendency to fatalism" index is reported as quarters, with students in the top quarter being more fatalistic about their success and failure and students in the bottom quarter being less fatalistic. As chart 4.11 indicates, there is a 61-point difference in science achievement scores between students in the top and bottom quarter for this index — students with stronger beliefs in fatalism have lower achievement in science.

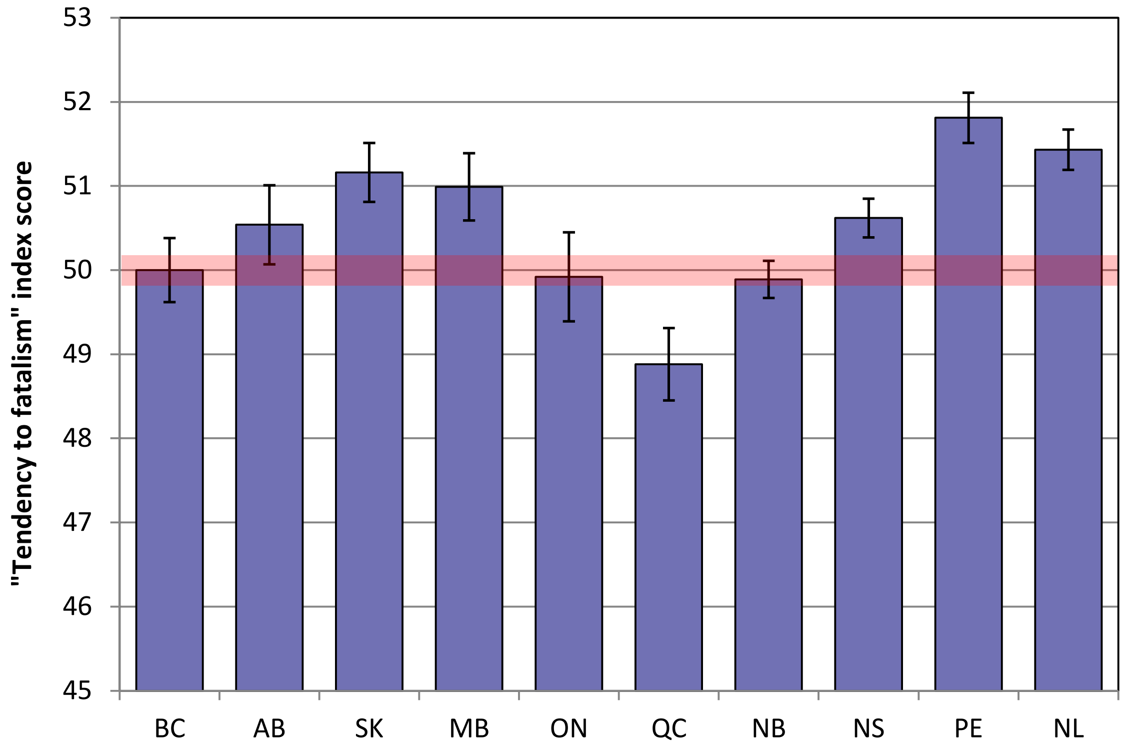
CHART 4.11 **Relationship between the tendency to fatalism index and science achievement**



Results by province

As chart 4.12 shows, the overall result for Canada is 50 ± 0.24. Students with the highest scores on the "tendency to fatalism" index are in Saskatchewan, Manitoba, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Students in Quebec are least likely to attribute their success or failure to factors outside their control.

CHART 4.12 **Average index scores by province: "Tendency to fatalism"**



Results by language

When scores on the "tendency to fatalism" index are compared within provinces, there is a significant difference between language systems in Saskatchewan, Manitoba, and New Brunswick. The students in English-language schools report a greater tendency to fatalism than those in French-language schools (see table 4.17). The same is true for Canada overall — students in the anglophone systems are more fatalistic than students in the francophone systems.

TABLE 4.17 **Average index scores by language: "Tendency to fatalism"**

	Anglophone schools		Francophone schools		Difference*
	Mean	CI	Mean	CI	
BC	50.1	0.4	48.1	2.1	2.1
AB	50.6	0.5	50.2	1.4	0.4
SK	51.3	0.3	48.4	1.5	2.9*
MB	51.1	0.4	49.4	1.2	1.7*
ON	50.0	0.6	49.8	0.7	0.2
QC	49.7	0.5	48.9	0.5	0.8
NB	50.7	0.2	48.8	0.4	1.9*
NS	50.7	0.2	50.5	0.5	0.2
PE	51.9	0.3	--	--	--
NL	51.5	0.3	--	--	--
CAN	**50.0**	**0.3**	**49.0**	**0.4**	**1.0***

* denotes significant difference

When compared to the Canadian means for the two language systems on this index, higher levels of fatalism are reported by anglophone students in Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Francophone students in Manitoba and Nova Scotia also report higher levels of fatalism. There is no significant difference in the other populations compared to the means of their respective Canadian English and French counterparts (see table 4.18).

TABLE 4.18 **Provincial results in relation to the Canadian average by language: "Tendency to fatalism" index**

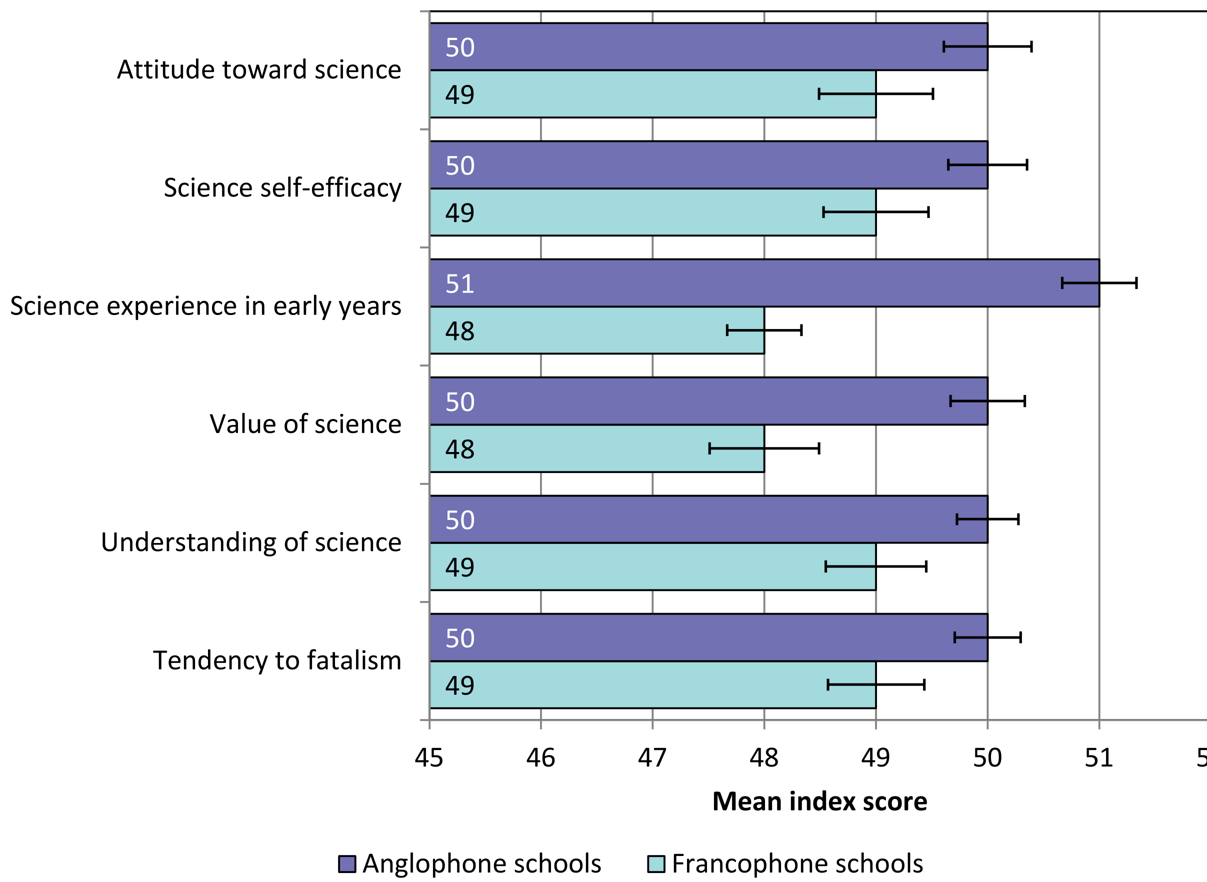
	Above Canada	At the same level as Canada	Below Canada
Anglophone schools			
	Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador	British Columbia, Alberta, Ontario, Quebec	
Francophone schools			
	Manitoba, Nova Scotia	British Columbia, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick	

Summary

Five student indices show positive relationships with science performance. Higher mean scores in science are found for students with high scores in the following indices: attitude toward science, science self-efficacy, experience with science in the early years, value of science, and understanding of science. One student index related to a student's tendency to fatalism shows a negative relationship with achievement in science.

For Canada overall, there is significant variation between students who attend anglophone and francophone schools. As chart 4.13 presents, students in English-language schools have index scores that are similar to those of Canadian students overall. However, their counterparts in French-language schools have lower scores on the six indices that are shown to have an impact science achievement.

CHART 4.13 **Results by language for indices that affect science achievement**



5 TEACHER CHARACTERISTICS

This chapter presents background characteristics for the sample of science teachers whose students participated in PCAP. These include gender, teacher specialization, and professional development. When relevant, the teacher characteristics are related to student achievement in science. Only those characteristics that were found to have a correlation coefficient of equal to or greater than 0.2 with science achievement are reported here.

The basic unit used to compute each mean in teacher-level charts is the mean calculated for all students taught by a teacher. Because the sampling for PCAP is based on whole classes, this represents the mean of all the student achievement results in a teacher's class. The reference to "mean science score — teacher level" reflects the fact that these are "means of means."[23] The school weight is used as a proxy for teachers' data because samples are drawn based on students and schools, and no weight was computed for teachers. Using the school weight reflects the aggregated nature of the estimated statistics. At the population level, these are different from the means computed overall for students because the number of students taught by a teacher in a given class differs across teachers and schools.[24] For this report, weighted values are used to report achievement data which are aggregated to classroom results for teachers; however, unweighted values are used for descriptive data reported by teachers.

Teacher gender

Teacher gender can matter because it shapes communication between teacher and student. Results of the National Education Longitudinal Survey (NELS) conducted in Grade 8 classrooms in the United States demonstrate that girls show better results when they are taught by women, and boys perform better when they are taught by men (Dee, 2006).

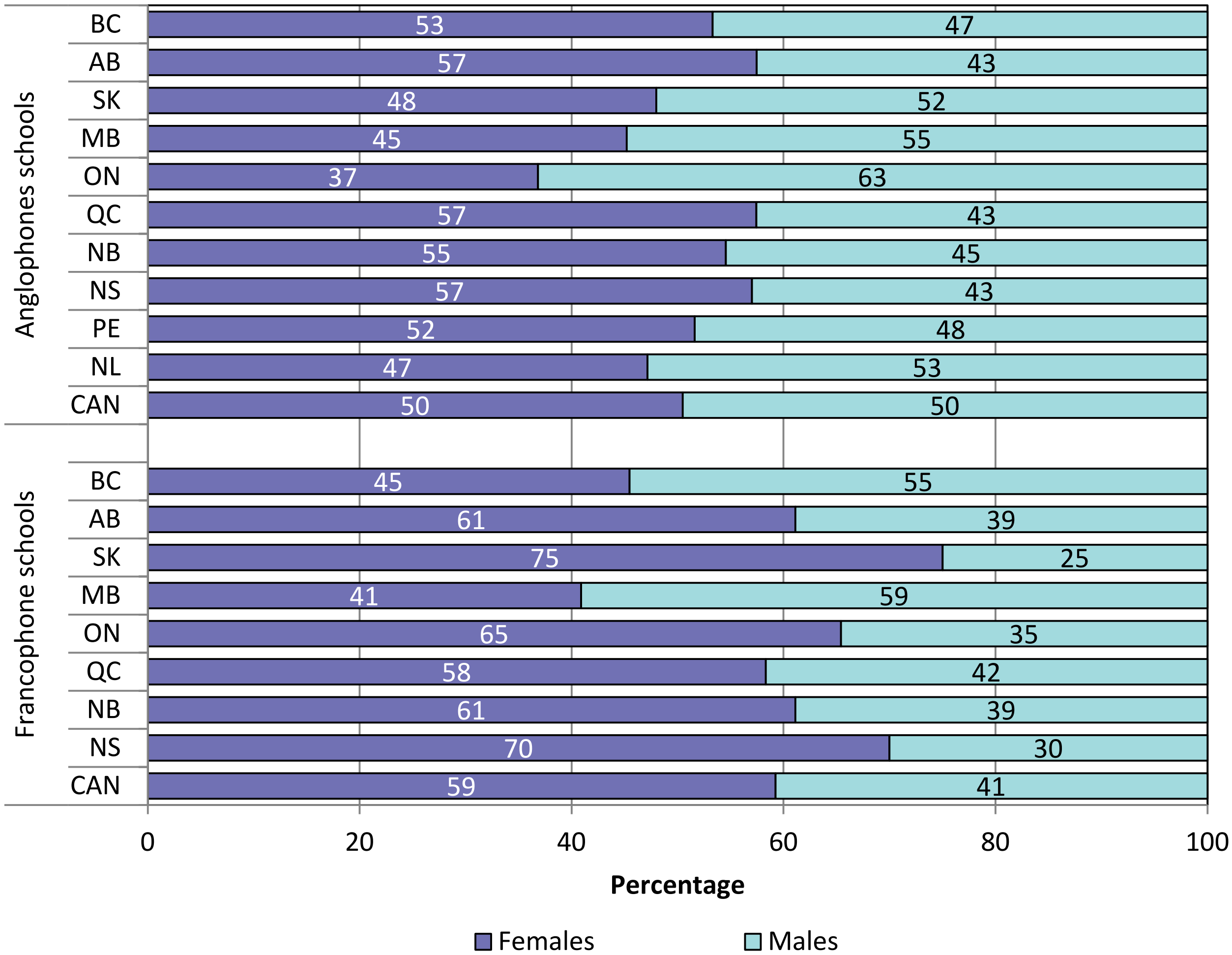
As chart 5.1 shows, there are more female than male Grade 8/Secondary II science teachers in francophone schools in Canada but the same proportion of each gender in anglophone schools.[25] Francophone schools in Saskatchewan have the highest proportion of female teachers (75 per cent) and the highest proportion of male teachers is found in anglophone schools in Ontario (63 per cent).

[23] The small number of samples can result in larger confidence intervals.

[24] The same principle applies to school-level charts where the basic unit is the mean for all students in a school and will be represented by "Mean science score — school level."

[25] Totals may not sum to exactly 100 per cent because of rounding.

CHART 5.1 **Proportion of male and female science teachers**



In Canada, at the Grade 8/Secondary II level, teacher gender does not significantly influence overall achievement in science (chart 5.2) nor is there an advantage if both teacher and student are of the same gender (chart 5.3). Although this appears contrary to the NELS results, it may have a subject-area focus. In PCAP 2010, students in classes taught by male teachers showed higher scores in mathematics (CMEC, 2012) but the opposite trend appeared for reading in PCAP 2007 where reading achievement was significantly higher in classes taught by female teachers (CMEC, 2009).

CHART 5.2 **Relationship between teacher gender and science achievement**

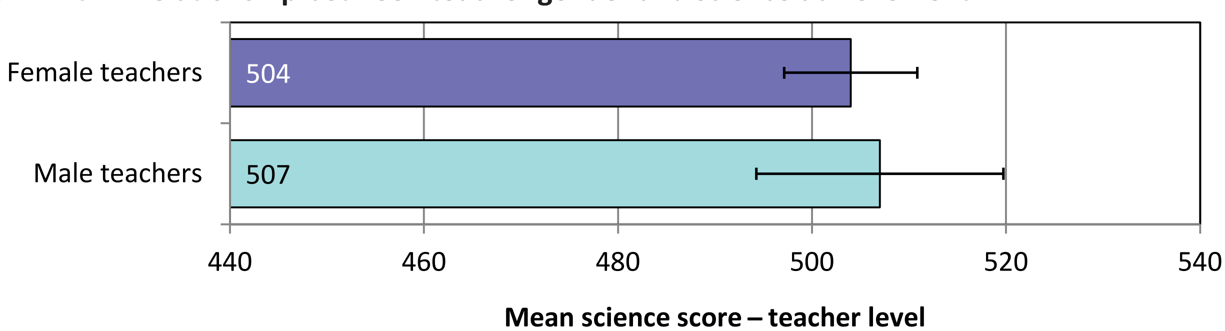
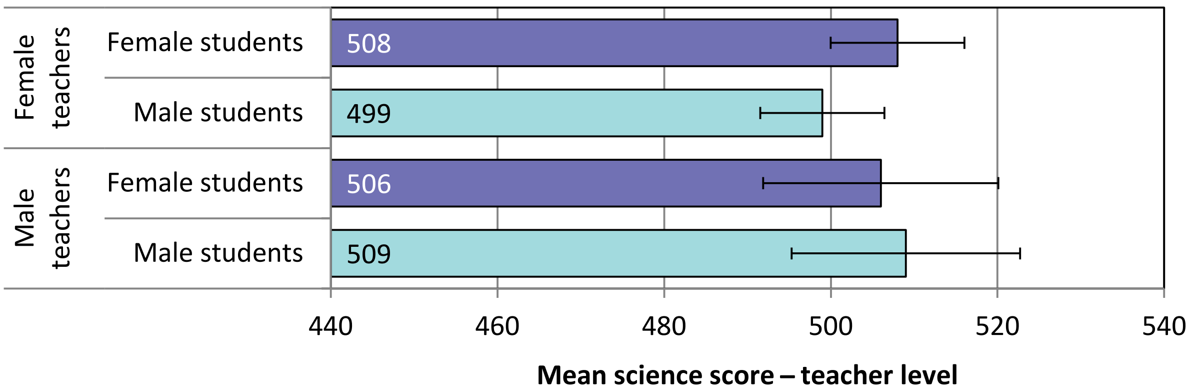


CHART 5.3 **Relationship between teacher gender, student gender, and science achievement**



Teacher specialization

There is widespread scholarly agreement that teachers should have a solid mastery of the content that they are teaching (Bolyard & Moyer-Packenham, 2008; Goldhaber & Brewer, 1996; Rice, 2003). According to an extensive review of the literature on science and mathematics teacher quality over the last 40 years by Bolyard and Moyer-Packenham (2008), evidence points to a generally positive association between subject matter preparation (as measured by subject-specific degrees and coursework) and student achievement.

In PCAP 2013, teacher specialization in science was measured in five questions related to teacher education, teacher experience, and teacher self-identification as a specialist.

- Teacher education includes (a) the degrees or diplomas earned and (b) the number of science or science-related courses completed during pre-service training.
- Teacher experience includes (a) the years of teaching practice and (b) the proportion of the teacher's assignment that is in science.
- Teachers were also asked to indicate whether they considered themselves a specialist by education or a specialist by experience in teaching science.

Teacher education

Grade 8/Secondary II school teachers generally become qualified to teach by completing a Bachelor of Education degree, either concurrently with an undergraduate degree or consecutively following the completion of the undergraduate degree from an accredited university. At least one supervised practicum in the field is required in any teacher education program. Its duration ranges from approximately two to six months depending upon the jurisdiction and accrediting institution. Some jurisdictions also require a qualifying examination, completion of a probationary teaching period, and/or completion of a mentoring or induction program that may provide another full year of professional support, including orientation, mentoring, and professional development in areas such as subject-specific content and processes, classroom management, and effective communication. In many jurisdictions or school districts, there are also incentives for teachers to further their qualifications by acquiring additional academic credentials or specialist courses. These incentives can be related to higher salaries or promotion. Data are available for teacher education requirements for mathematics teachers but no such study has been conducted for science teaching. The *Teacher Education and Development Study in Mathematics 2008 (TEDS-M)* surveyed teacher education in 17 countries, including several Canadian provinces (CMEC, 2010).

As table 5.1 shows, the vast majority of Canadian Grade 8/Secondary II teachers hold a Bachelor of Education degree. The highest proportions of teachers holding a Bachelor of Science degree (more than 80 per cent) are found in schools in British Columbia, Nova Scotia, and Newfoundland and Labrador. The highest proportion of teachers with graduate degrees (over 80 per cent) is found in the same jurisdictions with the addition of francophone teachers in Saskatchewan. A high proportion of teachers in most jurisdictions also report holding other degrees or diplomas (e.g., specialist certification).

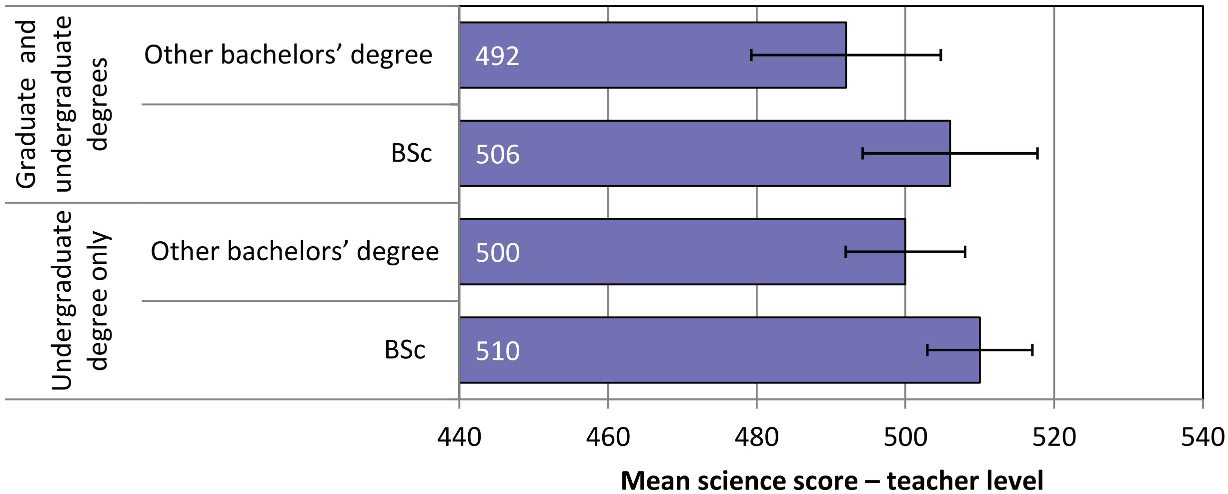
TABLE 5.1 **Academic credentials of Grade 8/Secondary II science teachers***

	Undergraduate bachelor degree				Graduate degree			Other degree or diploma	No degree or diploma
	BEd	BSc	BA	Other bachelor's degree	MEd	Other master's degree	PhD		
Anglophone schools									
BC	99	89	49	29	54	26	3	55	0
AB	99	72	44	26	25	19	3	21	0
SK	99	48	56	17	30	9	0	38	2
MB	98	59	71	41	10	14	7	35	0
ON	97	59	87	36	20	18	5	35	2
QC	95	67	67	25	16	32	4	29	4
NB	95	62	83	33	33	43	0	50	0
NS	99	86	64	19	62	23	0	52	0
PE	100	67	70	17	65	0	0	36	0
NL	100	86	50	35	70	18	3	37	0
CAN	**98**	**74**	**64**	**29**	**42**	**20**	**3**	**41**	**1**
Francophone schools									
BC	88	83	67	0	50	80	0	67	0
AB	100	67	17	0	33	25	0	25	0
SK	100	100	67	100	0	100	0	0	0
MB	100	29	71	0	7	14	0	50	0
ON	100	62	76	27	13	20	3	29	0
QC	92	71	8	22	11	15	2	30	0
NB	100	35	32	9	20	5	0	36	0
NS	100	83	33	33	33	50	33	50	0
CAN	**97**	**63**	**43**	**20**	**14**	**19**	**2**	**34**	**0**

* Teachers identified all degrees that they held; numbers represent percentages for each category.

There is a relationship between teachers' specialist education and their students' achievement in science, as chart 5.4 shows. Students taught by teachers with graduate degrees with no specialist training in science (i.e., a bachelor's degree other than a BSc) achieve statistically lower scores in PCAP 2013 than students taught by teachers with a BSc but with no graduate degree. No other relationship with teacher education and student achievement is statistically significant.

CHART 5.4 **Relationship between teacher education and science achievement**



To further elucidate the level of specialist training in science, teachers were asked to report the number of semester courses taken in science or science-related topics during their postsecondary studies. The results by jurisdiction and language of the school system appear in chart 5.5. The highest proportion of teachers who report taking 10 or more science courses is in British Columbia (anglophone schools — 71 per cent, francophone schools — 91 per cent) and Newfoundland and Labrador (67 per cent). The highest proportion of teachers reporting only one or two courses during their pre-service training is in Saskatchewan (anglophone schools — 45 per cent, francophone schools — 50 per cent) and francophone schools in New Brunswick (54 per cent).

CHART 5.5 **Number of postsecondary science courses completed as a measure of teacher specialization**

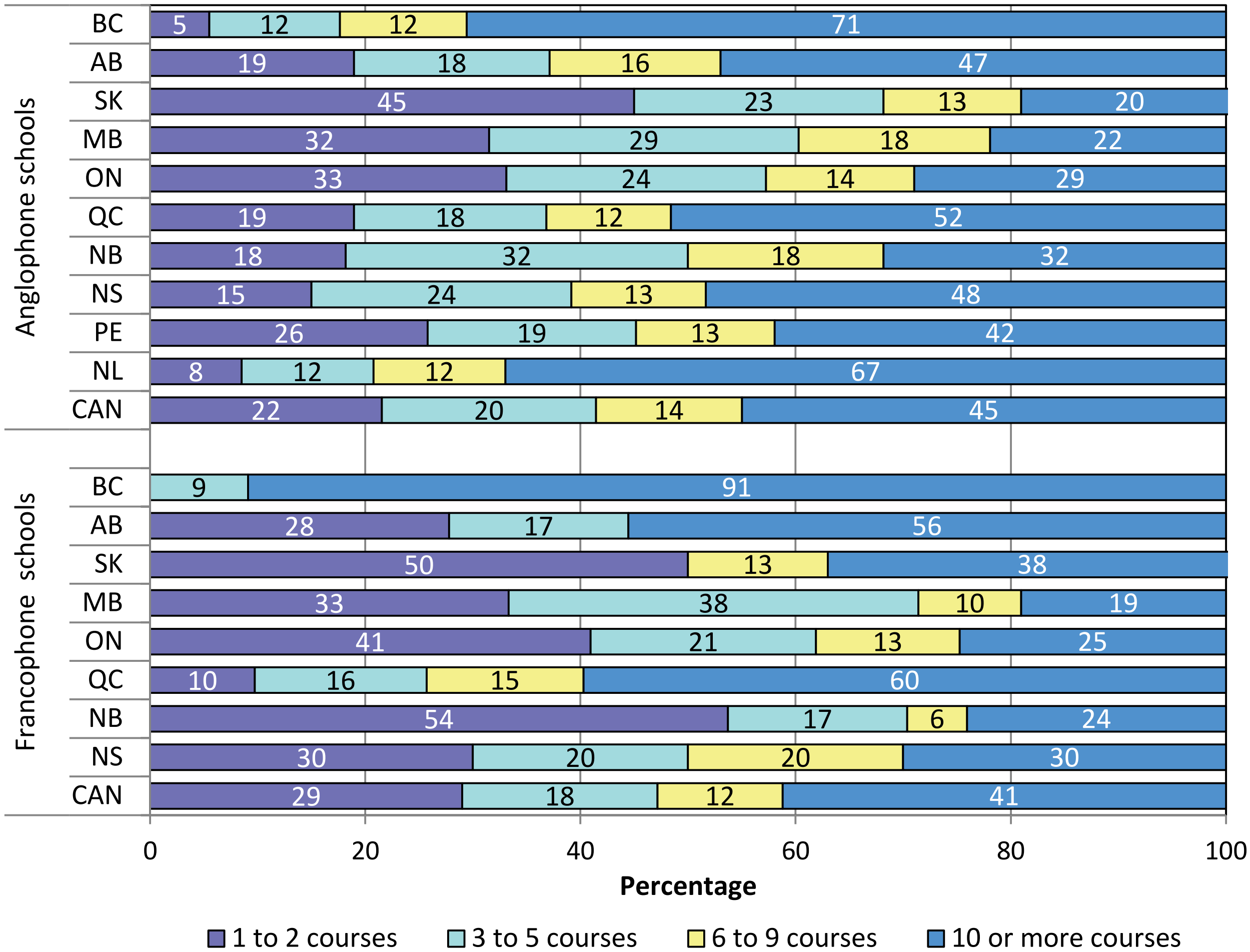
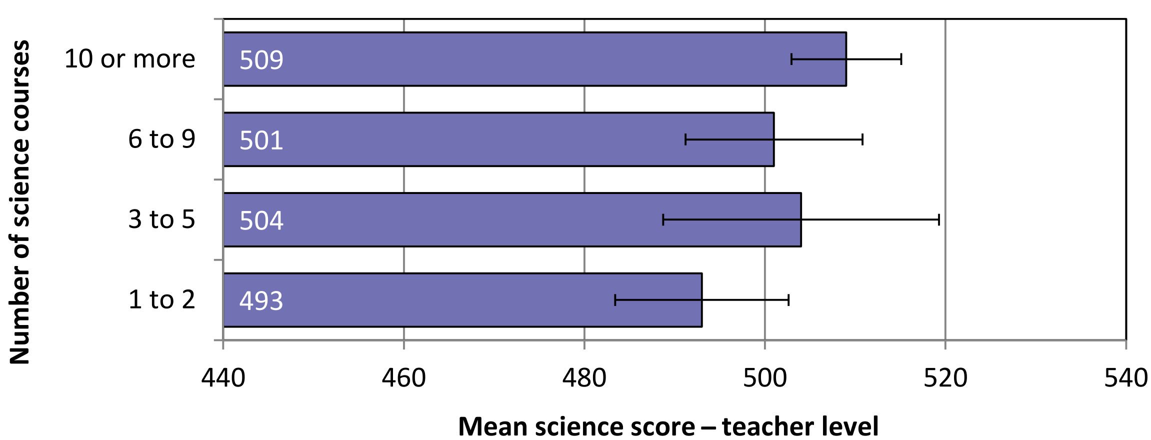


Chart 5.6 shows the relationship between the number of courses taken by teachers and their students' achievement in science. There is a significant difference in science scores in classrooms taught by the least specialized (1 to 2 courses) and the most specialized (10 or more courses) teachers.

CHART 5.6 **Relationship between teacher specialization and science achievement**

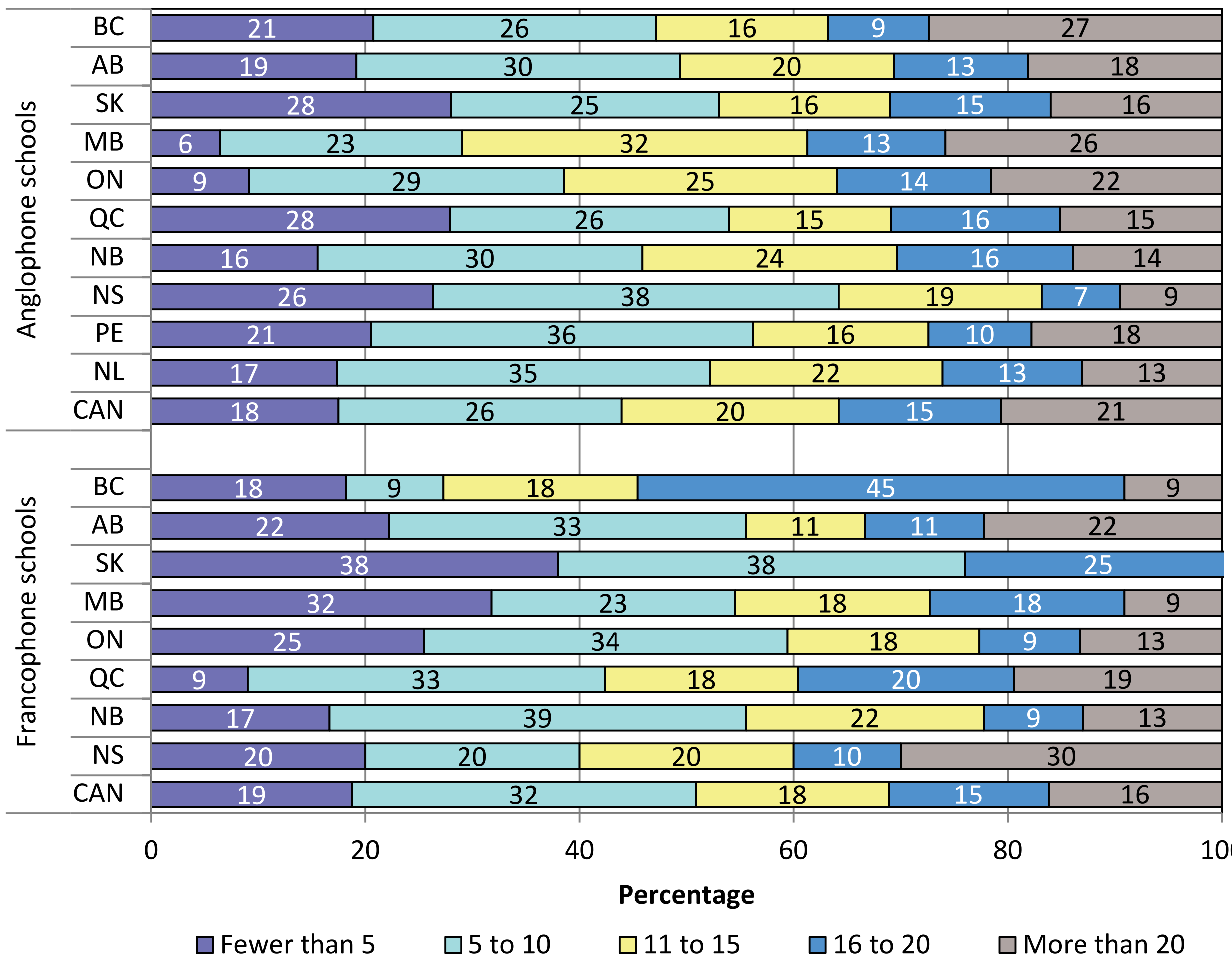


Teacher experience

It is generally assumed that “brand-new” teachers are not as effective as those with years of experience. Druva and Anderson’s (1983) meta-analysis of 65 studies reported a positive relationship between student outcomes in science and teachers’ experience. However, this relationship was not particularly strong. This is because the effects of teacher experience are rather complex and depend on a number of factors. For example, the experience impact is strongest during the first years of teaching, but after that, only marginal effects remain (Rice, 2010).

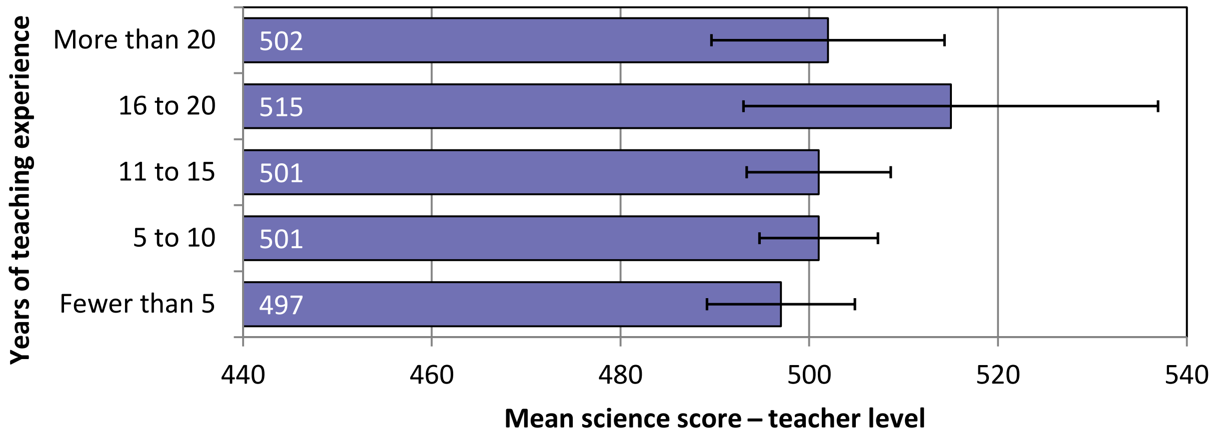
There is much variation in the teaching experience of Canadian Grade 8/Secondary II teachers as chart 5.7 indicates. At least 25 per cent of teachers have fewer than five years of teaching experience in anglophone schools in Saskatchewan, Quebec, and Nova Scotia and francophone schools in Saskatchewan, Manitoba, and Ontario. In contrast, at least 20 per cent of teachers have over 20 years of teaching experience in anglophone schools in British Columbia, Manitoba, and Ontario and in francophone schools in Alberta and Nova Scotia.

CHART 5.7 **Years of teaching experience for Grade 8/Secondary II science teachers**



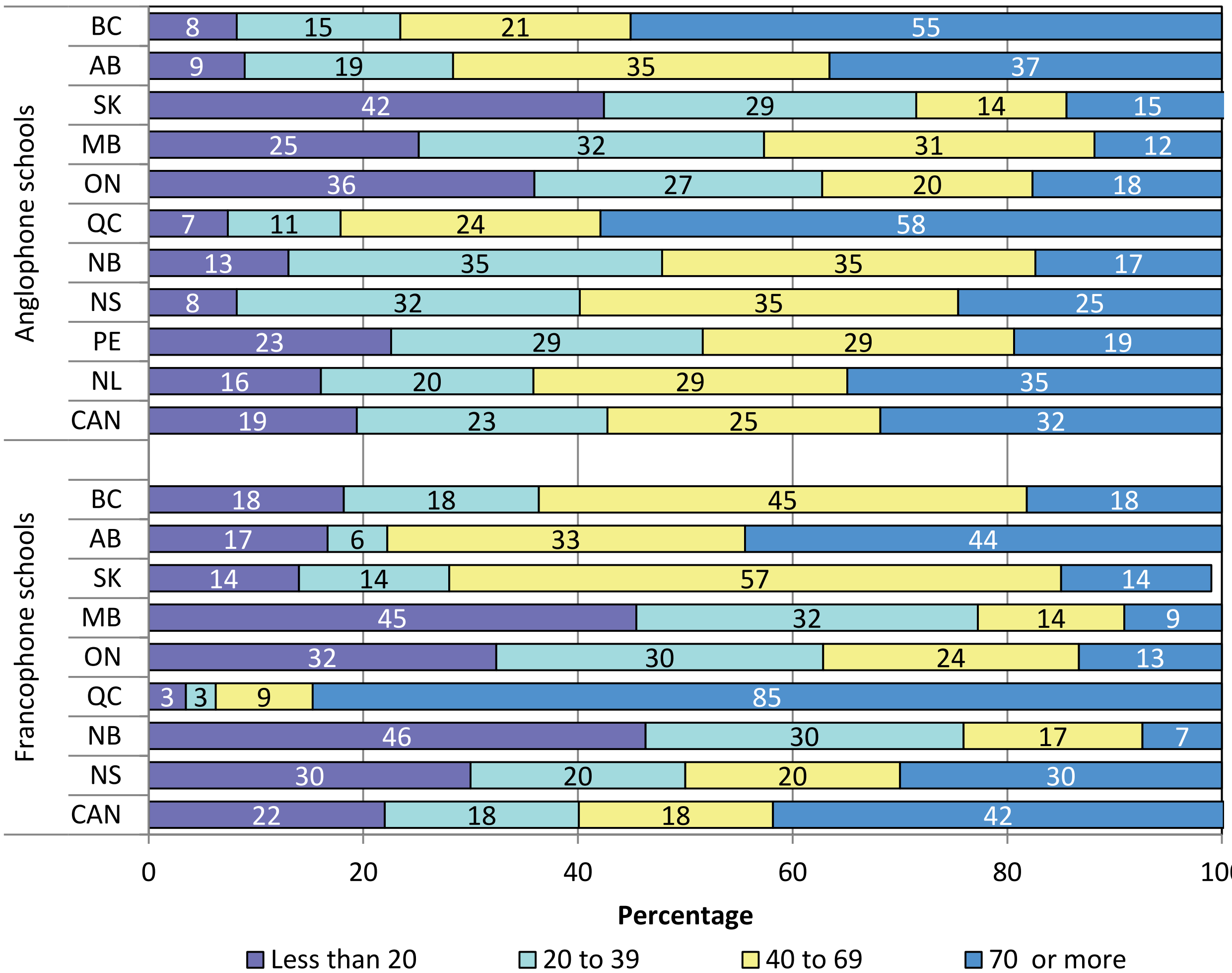
As chart 5.8 shows, there is no significant relationship between students’ science achievement and their teachers’ years of experience. This is not consistent with results from other national and international assessments. PCAP 2007, for example, reported higher reading scores for students taught by the most experienced teachers (CMEC, 2009). PCAP 2010 showed an increase in mathematics performance with teacher experience up to the 11- to 15-year range and a decline thereafter (CMEC, 2012). According to TIMSS 2011, higher science and mathematics achievement at the Grade 8 level internationally was related to teachers' having more teaching experience (Martin et al., 2012; Mullis et al., 2012a).

CHART 5.8 **Relationship between teachers' experience and science achievement**



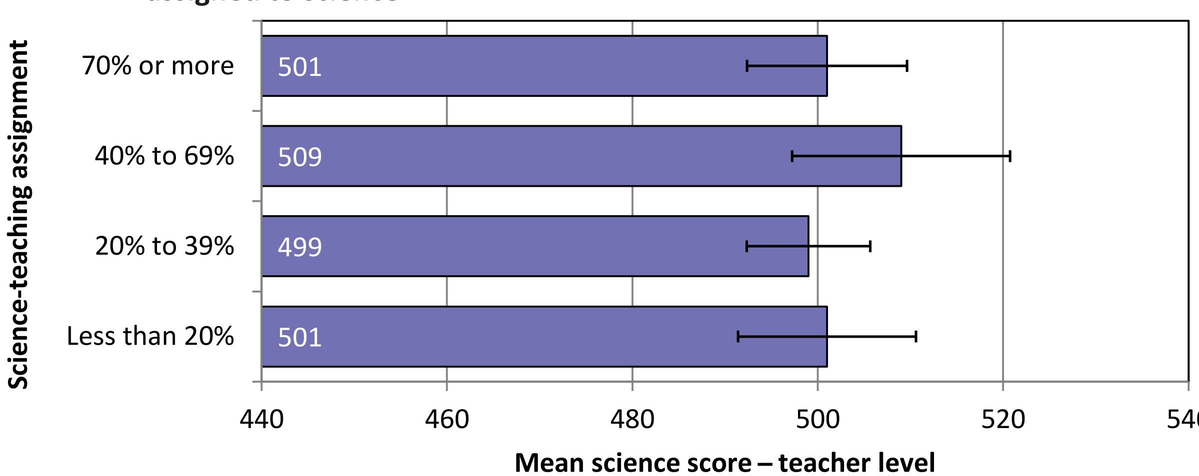
It is believed that the more time teachers spend on science instruction, the more they become confident and competent in this subject area. The science teachers of students writing PCAP 2013 were asked to indicate approximately what percentage of their total teaching time is assigned to science. Quebec stands out as having the highest proportion of teachers specialized in science based on their teaching assignment — 58 per cent of science teachers in Quebec's anglophone school system and 85 per cent in the francophone school system spend at least 70 per cent of their teaching time teaching science. As chart 5.9 shows, the results are quite variable across the country. At the other end of the scale, over one-third of teachers report that less than 20 per cent of their time is assigned to teaching science in anglophone schools in Saskatchewan and Ontario and francophone schools in Manitoba and New Brunswick. School structure may help to explain this variation. Depending on the structure of a school and organization of the school district, Grade 8/Secondary II teachers could be generalists teaching all subjects to a given class or they could be considered specialists and assigned to teach science to multiple grades and classes in a given school.

CHART 5.9 **Percentage of teachers' schedule assigned to science**



As chart 5.10 illustrates, the amount of a teacher's schedule devoted to teaching science has no significant impact on student achievement. This differs from the results reported for mathematics in PCAP 2010 which found higher achievement in classes with teachers assigned to teach more than 70 per cent of their classes in mathematics (CMEC 2012).

CHART 5.10 **Relationship between student achievement and proportion of teachers' time assigned to science**



Teacher self-identification as a specialist

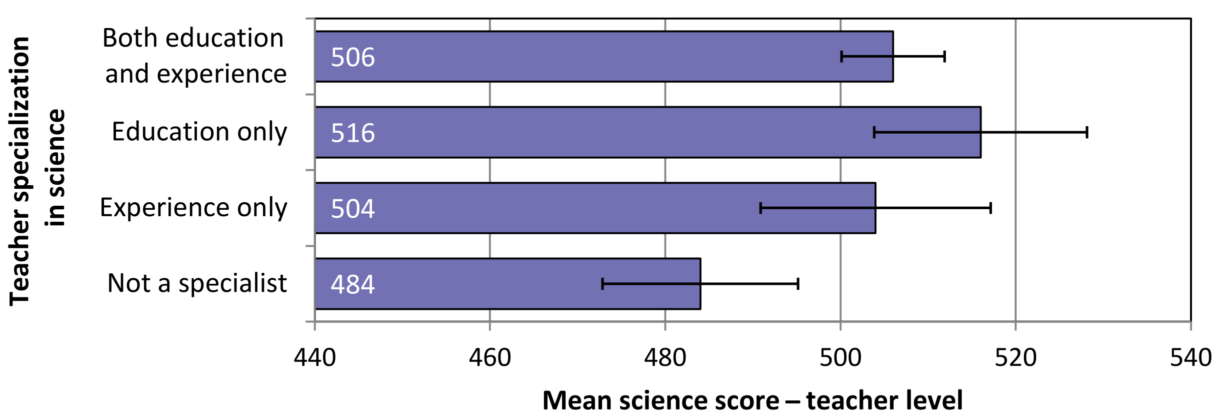
In the PCAP 2013 teacher questionnaire, teachers were asked whether they considered themselves a specialist *by education* or *experience* in teaching science. In most jurisdictions, a higher percentage of teachers consider themselves specialists by experience (table 5.2). Over 80 per cent of teachers identify themselves as specialists by education in anglophone schools in British Columbia and francophone schools in Quebec; likewise over 80 per cent of teachers identify themselves as specialists in science by experience in both schools systems in British Columbia and Quebec and in anglophone schools in Nova Scotia.

TABLE 5.2 **Percentage of teachers identifying themselves as science specialists**

	Anglophone schools		Francophone schools	
	Specialist by education	**Specialist by experience**	**Specialist by education**	**Specialist by experience**
BC	87	84	73	90
AB	60	77	61	76
SK	31	49	50	71
MB	44	61	23	36
ON	40	65	37	49
QC	71	84	81	91
NB	48	67	35	57
NS	67	83	38	70
PE	54	63	--	--
NL	70	74	--	--
CAN	**59**	**71**	**56**	**69**

As chart 5.11 indicates, students achieve significantly higher scores when they are taught by teachers who consider themselves specialists either by education, experience, or by both compared with those who did not consider themselves as specialists. The greatest difference in achievement (32 points) is found between classrooms with teachers who consider themselves specialists by education and those who consider themselves as nonspecialized.

CHART 5.11 **Influence of teacher specialization and student science achievement**



In Canada and internationally there is much discussion about the implementation of incentive programs to reward teachers as a means to improve student achievement. Although incentive programs might seem straightforward at first glance, they become quite complex when teacher quality must be defined or quantified. There is a rich debate about the models that could be used to identify teaching quality with a range of results. Some studies show that teacher quality appears to be unrelated to advanced degrees or certification, whereas experience does matter, but only in the first year of teaching (Hanushek, Kain, O'Brien, & Rivkin, 2005). Other studies reported that achievement in elementary and middle school increases significantly with teacher experience, with the largest gains in the first few years and continuing to a lesser extent in later years (Harris & Sass, 2011). It is interesting to note that the results of PCAP 2013 on teacher self-identification indicate that both forms of training — formal (education) and informal (experience) — lead to positive student achievement. This pattern is not confirmed when experience is based on the amount of science that a teacher teaches or on the degree of specialization in science during pre-service education.

Teacher professional development

Professional development (PD) for teachers in Canada is not linked to certification. In some countries, teachers must provide ongoing evidence of training to remain in good standing with their certification boards. In Canada, although professional development may contribute to career advancement, it is generally undertaken by individuals to hone their teaching craft. And it is optional rather than mandatory. There is a wide variety of PD accessible to teachers that can be pursued both individually and collaboratively, depending upon their needs. Examples include informal dialogue and reading professional literature; conferences, courses, workshops, and additional qualification programs; or participating in research, mentoring, or peer observation. Most school districts in Canada schedule professional development days that address specific school or district issues and initiatives. Across 23 participating countries in the Teaching and Learning International Survey (TALIS), the three areas most frequently reported by teachers as areas of high professional development need include teaching students with special learning needs, information and communications technology (ICT) teaching skills, and student discipline and behaviour problems (OECD, 2009). In that study, the most frequently reported PD activities that teachers identified were informal dialogue to improve teaching, courses and workshops, and reading professional literature.

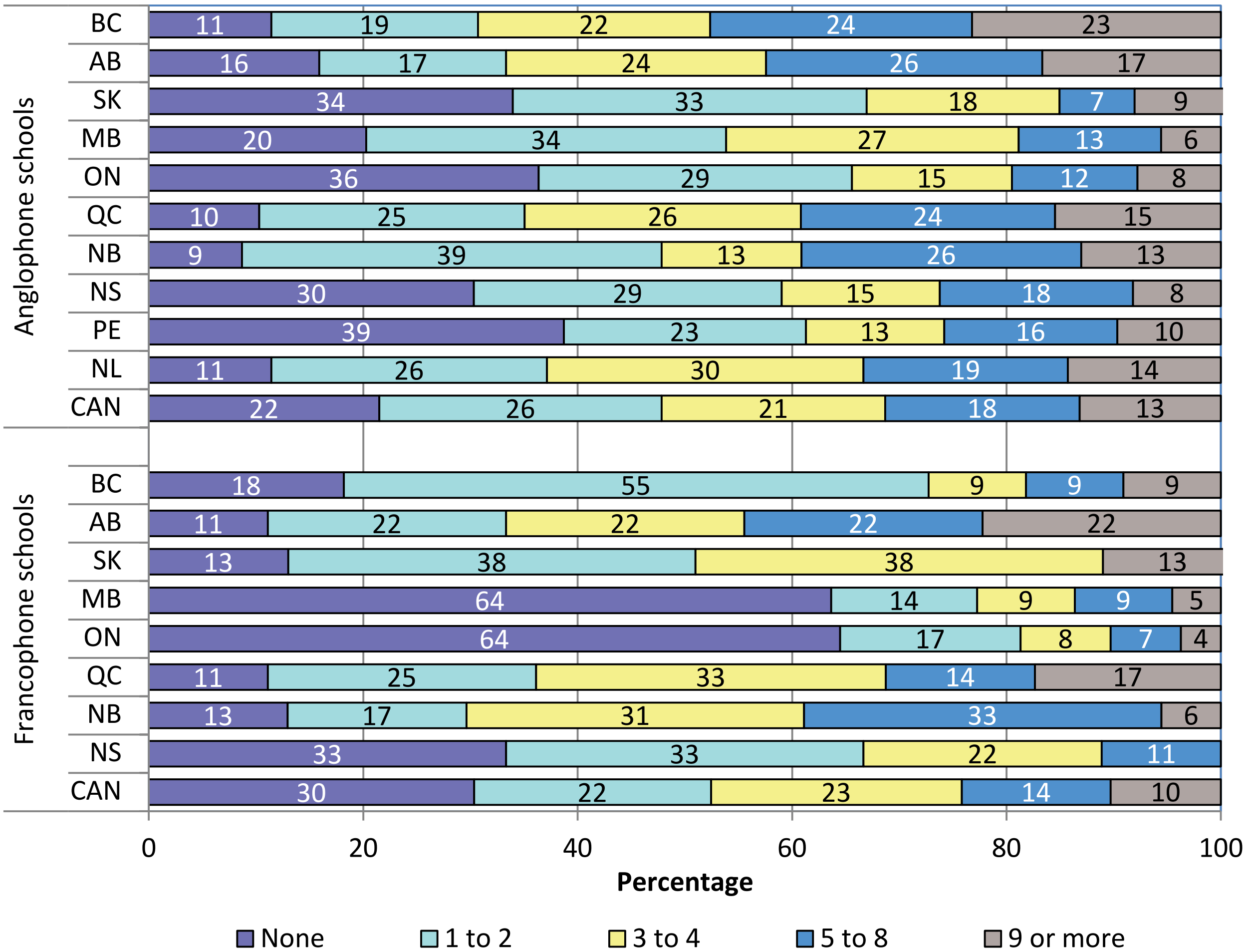
Overall in Canada, 96 per cent of Grade 8/Secondary II teachers report participating in professional development in the past five years. More teachers in English-language schools (97 per cent) have participated in professional development than in French-language schools (93 per cent). The participation rate varies from 93 per cent to 100 per cent in the anglophone system and from 80 per cent to 100 per cent in the francophone school system (table 5.3).

Table 5.3 **Percentage of teachers participating in professional development**

	Anglophone schools	Francophone schools
BC	99	100
AB	99	100
SK	93	100
MB	97	100
ON	97	90
QC	98	93
NB	100	94
NS	98	80
PE	94	-
NL	96	-
CAN	**97**	**93**

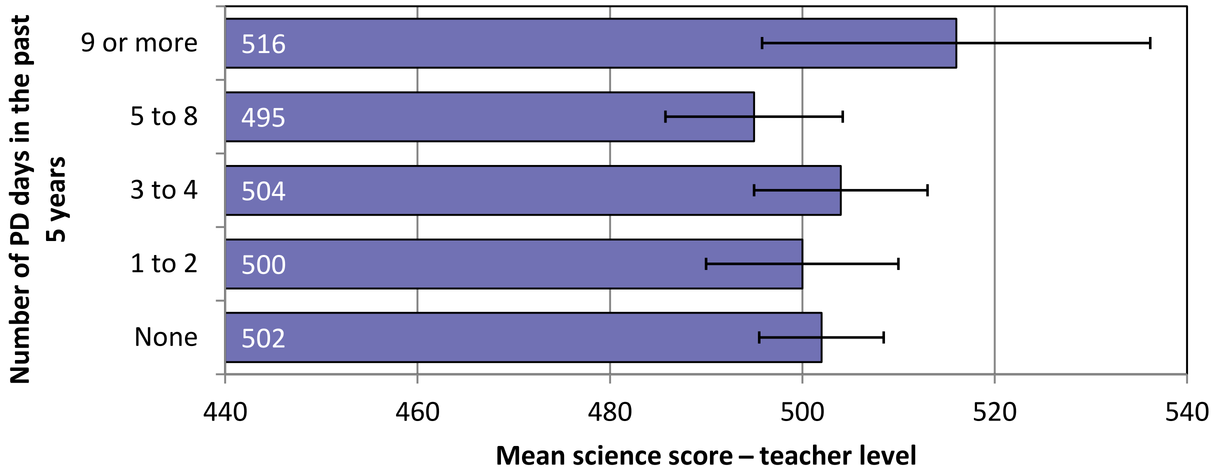
The number of science-related PD days that teachers participate in varies greatly across the country, as chart 5.12 shows. During the past five years, more than one in five teachers spent nine days or more on PD in science in anglophone schools in British Columbia and francophone schools in Alberta. By contrast, 64 per cent of teachers report that they did not attend any PD related to science teaching in the past five years in francophone schools in Manitoba and Ontario. There could be a variety of explanations for this. It may imply that as generalists, Grade 8/Secondary II teachers do not pursue content-specific PD or that they have a stronger need for development in other areas. Alternatively, teachers may not have easy access to PD opportunities focusing on science or PD sponsored by the school or district on broader topics may be more readily available to them.

CHART 5.12 **Number of days of science-related professional development during the past five years**



Nevertheless, there is no significant relationship between the number of science PD days and achievement in this subject (chart 5.13). This accords with other reports that found no consistent relationship between formal professional development training and teacher productivity in promoting science achievement (Harris & Sass, 2011). There are also studies showing that short PD experiences have no or very little effect on teaching — intensive and sustained PD of over 80 hours is needed to produce positive results (Supovitz & Turner, 2000).

CHART 5.13 **Relationship between student achievement and science-related professional development**



To explore the variety of PD that teachers participate in, they were asked to identify both the types of professional development in which they had participated and its effect on student learning using a three-point scale: "little or none," "some," or "a lot." Items are related to both general PD topics and topics that are specific to teaching science, as table 5.4 shows.

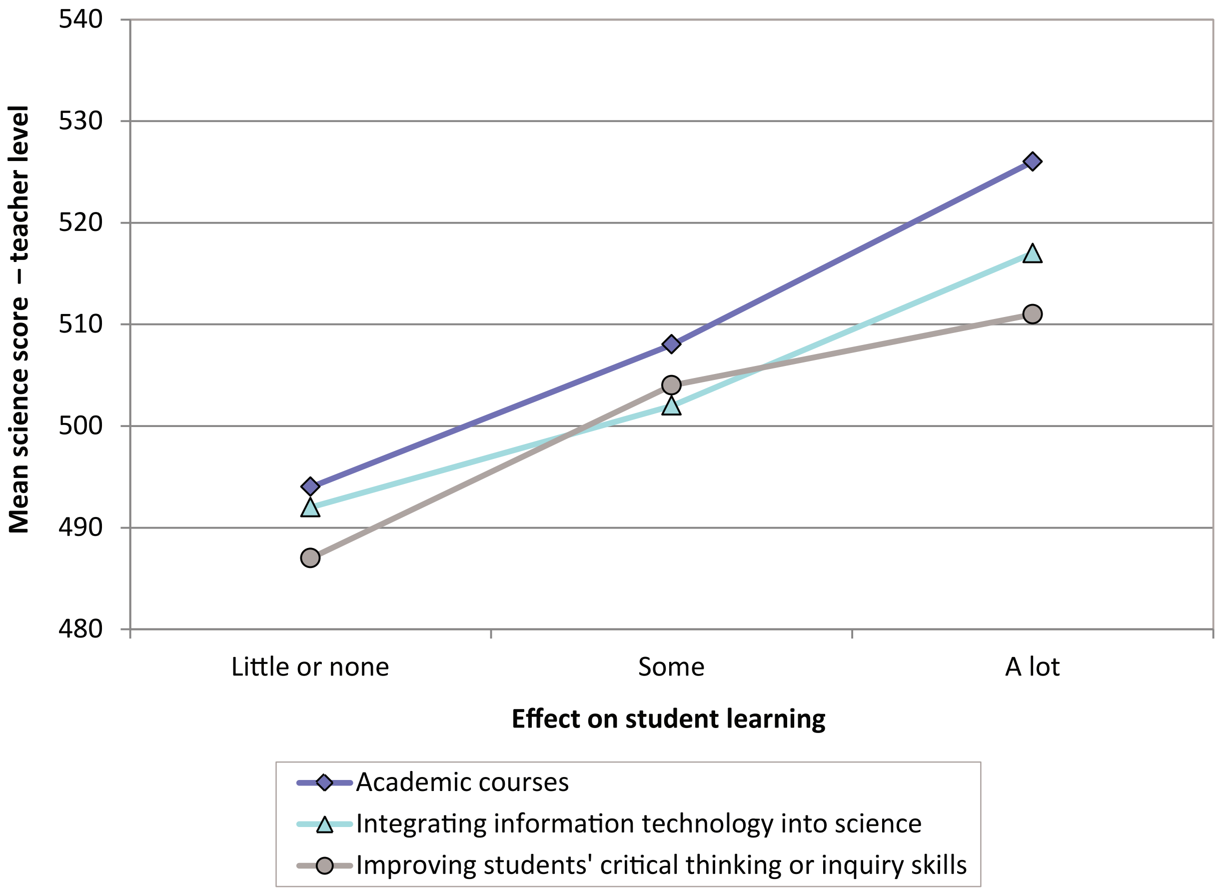
TABLE 5.4 **Questionnaire items for teacher participation in PD's effect on student learning**

Have you participated in professional-development activities on the following topics in the past five years? If YES, indicate their effect on student learning.
General PD
Academic courses (e.g., university)*
Workshops or conferences
Professional learning communities
Curriculum development
Development of common assessment items
Marking or scoring sessions
On-line (e.g., webinars, videos)
Integrating information technology into science (e.g., SMART Board, probeware, smart phones)*
Assessment and evaluation
Differentiating instruction/resources to adapt to students' learning styles, interests, and needs
Science-specific PD
Science content
Science pedagogy/instruction (e.g., inquiry)
Science curriculum
Professional science reading materials
Science teacher collaboration
Improving students' critical thinking or inquiry skills*
Science assessment

* indicates a significant linear relationship with student science achievement

Three types of professional development listed in table 5.4 have a positive, linear relationship with student achievement in the PCAP 2013 assessment of science: academic courses, integrating information technology (IT) into science, and improving students' critical thinking or inquiry skills. For these three areas, student achievement is higher in classrooms with teachers who report that professional development has an impact on their students' learning (chart 5.14). Other studies report a positive relationship between professional development and student achievement. For example, the use of inquiry-based teaching practices, which requires practitioner training, was reported to lead to improved student achievement in science (Supovitz & Turner, 2000).

CHART 5.14 **Teacher attitudes toward professional development: Effect on student learning**



Among the 96 per cent of Canadian teachers overall who participated in PD during the last five years, 86 per cent focused on integrating IT into science, 71 per cent took academic courses, and 61 per cent worked on improving students' critical and inquiry skills. Tables 5.5 and 5.6 present teacher percentages by population for the three types of PD that have shown a significant relationship with student achievement. As table 5.5 shows, the majority of jurisdictions in both language groups emphasize IT integration into science. Francophone schools in British Columbia and Nova Scotia stand out as equally emphasizing each of the three topics found to significantly impact achievement in their PD activities.

Table 5.5 **Percentage of teachers participating in PD activities that are positively related to science achievement[26]**

	Integrating IT into science	Academic courses	Improving critical thinking or inquiry skills
Anglophone schools			
BC	92	78	79
AB	87	78	74
SK	84	76	61
MB	89	75	64
ON	89	70	66
QC	87	74	61
NB	83	83	65
NS	90	85	62
PE	86	79	45
NL	96	81	73
CAN	**89**	**77**	**68**
Francophone schools			
BC	55	55	55
AB	94	41	35
SK	88	50	38
MB	82	59	32
ON	80	70	24
QC	71	39	32
NB	69	55	63
NS	25	25	25
CAN	**74**	**52**	**35**
CAN overall	**86**	**71**	**61**

Within jurisdictions, as readers can see in table 5.6, teachers in francophone schools report that their participation in PD related to integrating IT into science and taking academic courses had more of an effect on their students' learning than teachers in anglophone schools. At least one-third of anglophone teachers report that integrating IT into science has a high impact on student learning in Alberta, Ontario, and New Brunswick, whereas a similar level of effect is reported by a higher proportion, at least one-half, of francophone teachers in Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, and Nova Scotia. For academic courses, 50 per cent of francophone teachers in British Columbia and Nova Scotia report a high positive impact on their students' learning and in anglophone schools, the highest proportion of teachers reporting a similar level of impact is in Nova Scotia (32 per cent). A strong positive relationship between PD and improving critical thinking or inquiry skills is reported in the highest proportions in francophone schools in British Columbia

[26] Percentage was calculated as the number of teachers for a particular PD activity divided by the total number of teachers participating in PD.

(50 per cent) and Saskatchewan (67 per cent), and to a lesser extent in anglophone schools in Alberta (29 per cent), Ontario (28 per cent), and New Brunswick (27 per cent).

TABLE 5.6 **Proportion of teachers who participated in PD activities and reported that it affected their students' learning "a lot"**

	Integrating IT into science	Academic courses	Improving critical thinking or inquiry skills
Anglophone schools			
BC	26	26	22
AB	33	22	29
SK	27	20	15
MB	29	19	25
ON	35	13	28
QC	28	13	21
NB	37	11	27
NS	21	32	11
PE	26	13	23
NL	31	20	16
CAN	**29**	**21**	**22**
Francophone schools			
BC	33	50	50
AB	63	29	17
SK	57	25	67
MB	61	31	29
ON	56	18	26
QC	44	23	19
NB	60	39	34
NS	50	50	0
CAN	**51**	**28**	**22**

Summary

This chapter examined characteristics of Canadian Grade 8/Secondary II teachers including gender, teacher specialization, and professional development.

There is a relationship between teacher training and student achievement. Higher levels of both formal (education) and informal (experience) training are significantly related to higher student achievement. Students also achieve significantly higher scores when they were taught by teachers who consider themselves specialists either by education, experience, or by both.

Three types of professional development have a significant linear relationship with student achievement in the PCAP 2013 assessment of science: integrating information technology (IT) into science, academic courses, and improving students' critical thinking or inquiry skills. For these three areas, student achievement is highest in classroom with teachers who believe that professional development has an impact on their students' learning.

Teacher gender, teachers' years of experience, the amount of a teacher's schedule devoted to teaching science, and the number of days of science-related professional development are not significantly related to student achievement in science.

6 INSTRUCTIONAL CLIMATE

Effective instructional leaders nurture and develop a school climate where learning is valued. Instructional climate refers to features of the school and classroom climate that can be expected to have an impact on achievement. This chapter explores aspects of the school's overall philosophy and areas of emphasis in science through the teacher questionnaires. This contextual information is presented descriptively by jurisdiction and language of the school system and with respect to the impact on science achievement. The science content and topic areas that PCAP 2013 assessed are elaborated in the *PCAP Science Assessment Framework*;[27] the sub-domains and processes represent the common elements of provincial and territorial science curriculum in participating jurisdictions.

The chapter examines characteristics of classes, methods that teachers use to meet the needs of all students, teaching strategies, challenges to teaching, and teachers' efficacy and beliefs. The impact of teacher absenteeism and having an adult other than the students' teacher in the classroom is also analyzed. The results of several regression models help make sense of the complex interrelationship of teaching and learning in a school environment.

Characteristics of classes

Two characteristics of classes are discussed here: (1) the class size and (2) the classroom organization.[28]

Class size

Classroom management is related to the diversity of students in a classroom and teachers' preferred teaching styles. Factors that can influence the management of a classroom include class size and how teachers organize their students and classrooms for instruction.

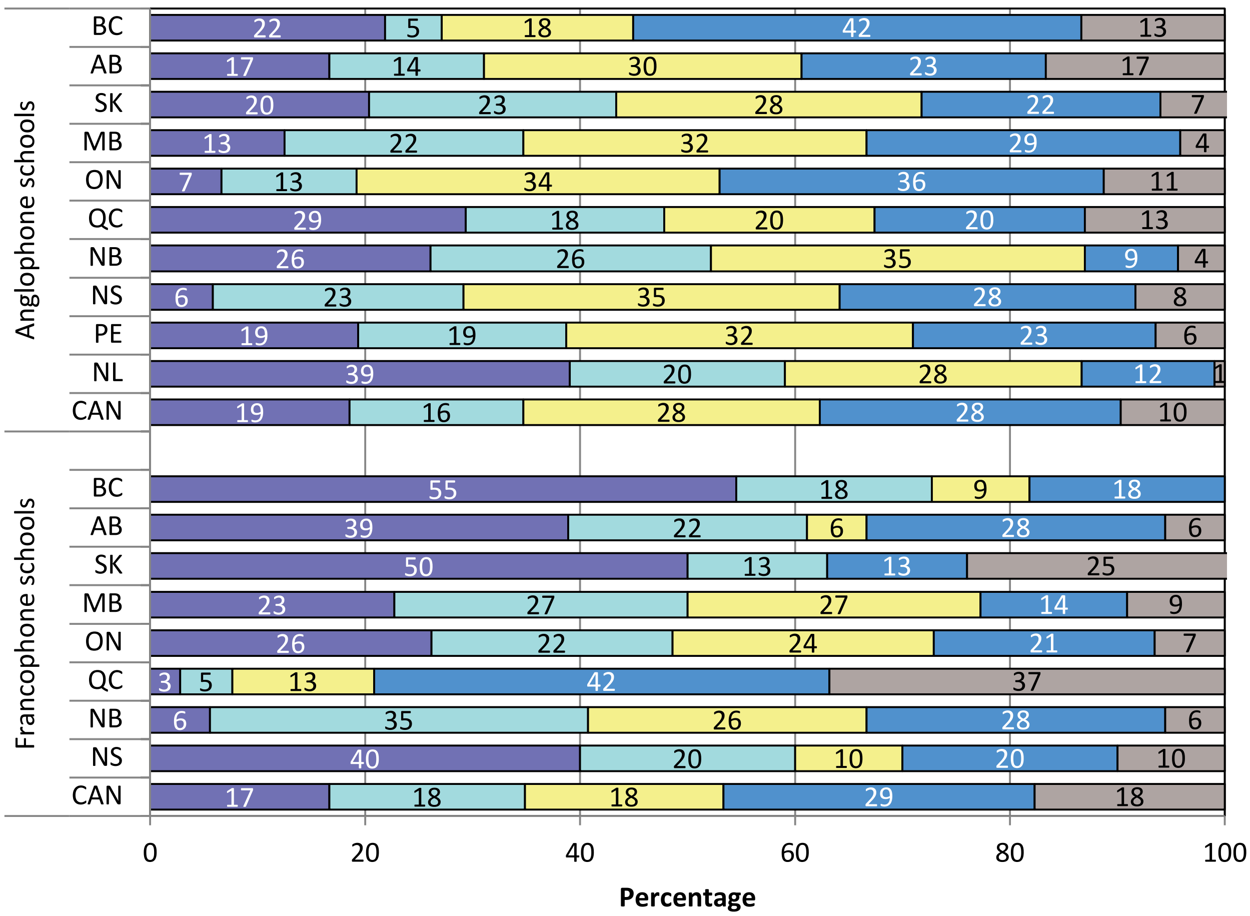
Class size information was obtained by asking teachers to report the number of students in the science class selected for PCAP 2013. As chart 6.1 shows, there is a lot of variation between populations.[29] The highest proportion of small classes is found in francophone schools in British Columbia and Saskatchewan with 50 per cent or more of teachers reporting classes with fewer than 15 students. Almost 40 per cent of teachers also report such small classes in Newfoundland and Labrador, and in francophone schools in Alberta and Nova Scotia. Francophone schools in Quebec have the highest percentage of classes with 30 or more students (37 per cent) and approximately 15 per cent of teachers in anglophone schools in British Columbia, Alberta, and Quebec report such large classes.

27 Available at http://www.cmec.ca/docs/pcap/pcap2013/PCAP-2013-Science-Assessment-Framework-EN.pdf

28 Data were also collected on the number of grade levels in the selected class. However, these data are not presented in the main report because the vast majority of classes have only one level and only 2 per cent of the classes have three levels. As can be expected, achievement in science is not associated with this variable.

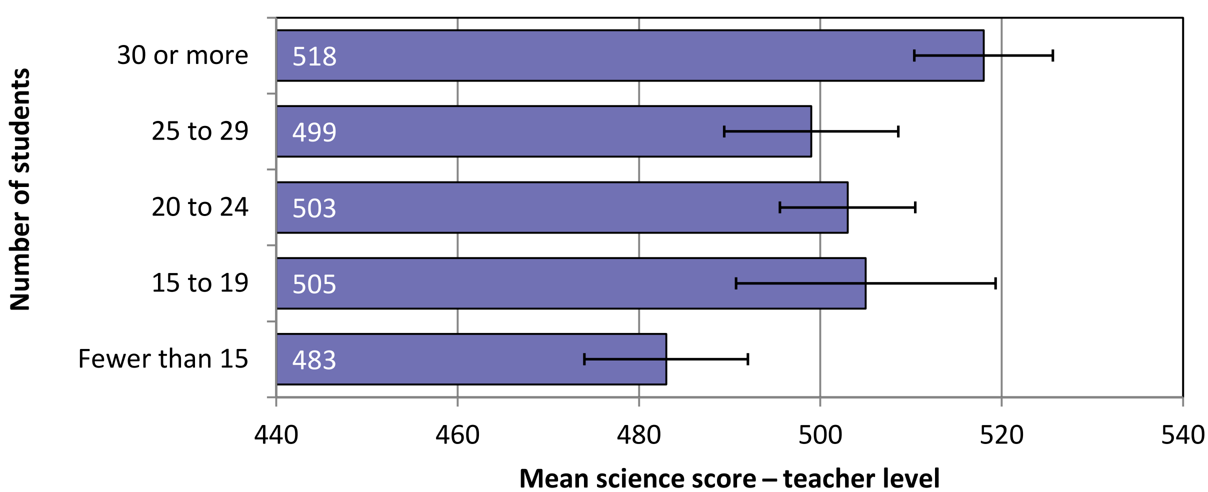
29 Totals in these charts may not sum to exactly 100 per cent because of rounding.

CHART 6.1 **Class size in Grade 8/Secondary II science classes**



The PCAP 2013 data indicate that students in classes with 30 or more students achieve the highest scores in science and the lowest scores are achieved by student in classes with fewer than 15 students, as chart 6.2 shows. No significant differences in achievement are found between classes that ranged from 15 to 29 students, although the majority of classes participating in the study were in this range.

CHART 6.2 **Relationship between class size and achievement**



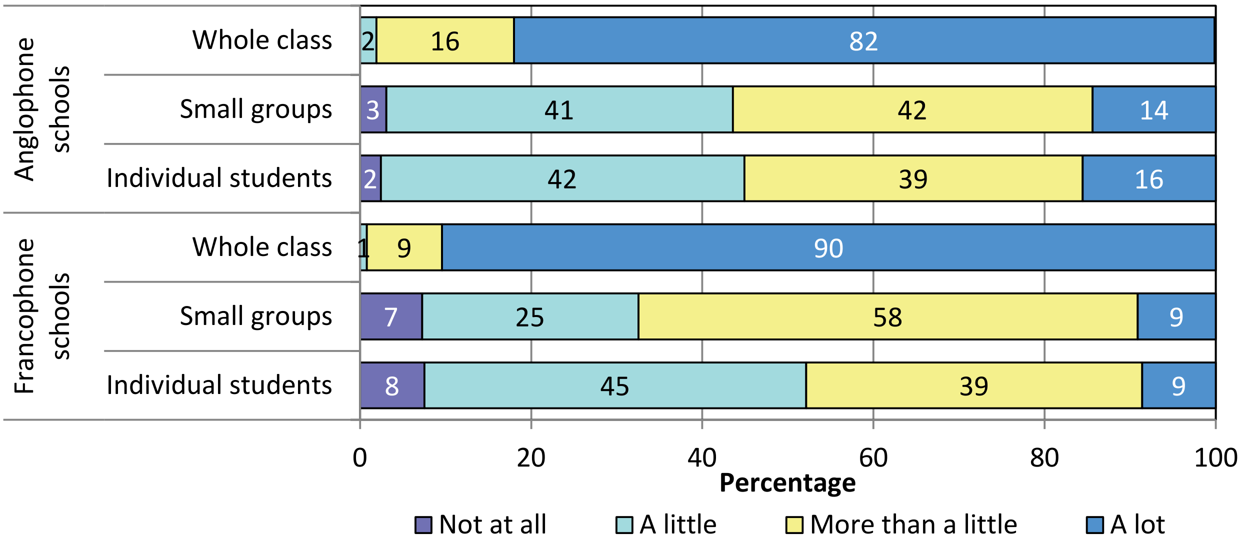
Class size reduction is a topic of significant discussion in many levels of education systems. It is one of the most expensive policies for ministries of education to implement because for a school to reduce class sizes, more teachers are required with the concomitant increase in budget needs to cover teacher salary and benefits. Parents like small classes because their experience suggests that fewer children results in more individualized attention. Teachers, teachers' unions, and administrators like smaller classes for the same reasons that parents do but also because they are influenced by issues related to managing students and teacher workload. One of the key reasons that class size is controversial is that the empirical evidence is contradictory. This may be partly a result of the number of factors that influence student achievement that are inherently nonrandom. For example, class composition is influenced by factors such as school location and resources, parent choices, and school board policy. Although the results presented in this report seem counterintuitive, they support findings from other large-scale assessments such as SAIP and PISA. However, other studies have found that the relationship between class size and achievement is not significant (Hoxby, 2000). According to Finn (2002), if the goal of class size reduction is to increase achievement by focusing more on individual students, then it must be paired with professional development for teachers to become an effective measure.

Organization of the class

Teachers were asked to what extent they taught (a) to the whole class, (b) to a small group, and (c) to individual students. These questions are assumed to reflect the preferred teaching styles that teachers use to organize their classrooms for instruction. Although the composite score derived from these items related to the class's organization is not significantly related to achievement in science, a high proportion of teachers in Canada report that they teach to the whole class the majority of the time. Indeed, 82 per cent of anglophone teachers and 90 per cent of francophone teachers report that they teach to the whole class "a lot" as chart 6.3 indicates.

Given the importance of these two characteristics, further analysis at the items level was carried out to determine whether at least one of the three teaching styles was related to achievement. The results reveal that teaching to individual students is significantly associated with the science outcome. Specifically, when the class size is small, teaching to individual students has no significant impact on the average achievement but there is a negative relationship between individual instruction and science achievement in large classes. This does not imply a causal relationship — in a class with many students, the teacher is not able to give as much time to individual students as would be the case in a smaller class. The effectiveness of class-size-reduction strategies may improve with a more varied approach to classroom organization for science lessons because, especially for older students, small-group learning is effective in promoting academic achievement, positive attitudes, and greater persistence (Springer, Stanne, & Donovan, 1999).

CHART 6.3 **Classroom organization used by teachers in science class**



Instructional methods

A 17-item frequency scale was used to determine the strategies teachers use in their science classrooms. As table 6.1 presents, a three-factor solution emerged from these items that shows varying impact on science achievement. The results of survey regression analysis show that the first factor, the traditional science strategies, shows a negative association with achievement. This factor involves approaches that are considered more traditional such as using textbooks or routine problem solving. The next two factors can be thought of as different levels of inquiry-based teaching. Hands-on and collaborative strategies, or teacher-supported inquiry activities, involve students being guided through hands-on activities, typically in laboratory groupings in science class. This type of teaching is associated with significantly higher student achievement. The last factor, open science inquiry strategies that involve students planning and designing investigations, was not found to be significantly associated with achievement. The difference in influence on achievement between these last two factors may be partly a result of how frequently teachers use the various strategies. Chart 6.4 presents the extent to which teachers report using traditional, teacher-supported inquiry, and student-directed inquiry strategies listed by decreasing frequency of use in each category. Almost 80 per cent of teachers report that their students do teacher-supported inquiry activities “a lot” or “more than a little,” whereas closer to 50 per cent of teachers report a similar frequency in the use of student-directed inquiry activities.

Table 6.1 **Strategies used by teachers during science instruction**

Factors	To what extent do you ask the students to do the following during science instruction?
Negative relationship with achievement	
Traditional science teaching methods (no inquiry)	Watch you demonstrate an experiment or investigation. Read their textbooks or other resource materials. Memorize facts and principles. Use scientific formulas, laws, or theory to solve routine problems. Relate what they are learning in science to their daily lives. Learn process skills in context. Make connections to other disciplines.
Positive relationship with achievement	
Hands-on science and collaborative methods (teacher-supported inquiry)	Conduct experiments or investigations. Work together in small groups on experiments or investigations. Learn through exploration. Interact with their peers. Experience something new.
No significant relationship with achievement	
Open science inquiry methods (student-directed inquiry)	Observe natural phenomena and describe what they see. Formulate their own questions for investigation. Design ways to seek answers to their own questions. Design or plan experiments or investigations. Be inventive or creative.

CHART 6.4 **Extent to which teachers use specific strategies in their science class**

This study confirms the conclusions of Schroeder and colleagues (2007) that alternative teaching strategies have a more positive influence on student achievement compared with the traditional teaching methods. However, debate continues regarding the effectiveness of inquiry-based teaching in science. Previous meta-analyses have concluded that inquiry teaching has inconsistent effects on student science achievement. Some studies have shown positive effects (e.g., Minner et al., 2010; Schroeder et al., 2007) and others have shown negative effects (e.g., Kirschner, Sweller, & Clark, 2006). Using student-reported data from PISA 2006 related to teachers' use of inquiry strategies, Jiang and McComas (2015) found a positive association between achievement and inquiry-based instruction but reported contradictory effects regarding the level of openness in inquiry-based teaching. Higher achievement was associated with students who reported that their teachers used teacher-supported inquiry instruction (e.g., conduct guided activities and draw conclusions from data), whereas the use of student-directed inquiry (e.g., designing experiments) was associated with lower achievement scores, but more positive attitude scores. This may be explained by recognizing that student-directed inquiry requires more time. Students require more time on task to develop and test their ideas. Teachers also need more time. To facilitate effective open inquiry with students, teachers need a deep understanding of curriculum, clarity of learning goals, pedagogical knowledge to translate teaching and learning, and effective teacher-student questioning skills.

In a study with older students, O'Grady-Morris (2008) proposed that students do not readily make connections between multiple representations on their own during science activities and often hold disparate explanations for the same phenomena presented to them in the laboratory and in the classroom. Thus minimally guided instruction, such as more open science inquiry, can be less effective and less efficient than instructional processes that guide student learning because of the need to help the student make explicit connections between their observations and the abstract models used to explain scientific principles. Often teachers assume that students have made implicit connections between lesson content and their prior knowledge as they work through the experimental process but the development of conceptual knowledge is also informed by strongly held and persistent misconceptions that result from the overgeneralization of scientific theory (O'Grady-Morris, 2008; O'Grady-Morris & Nocente, 2009). Instruction that is more guided could increase the opportunity for misconceptions to be both recognized and challenged in a fruitful way.

As PCAP 2013 shows, student-directed inquiry activities that are considered more open or high-level strategies do not significantly improve student achievement in science. Wise (1996) concluded that innovative science instruction is a mixture of teaching strategies and no one strategy is as powerful as utilizing a combined-strategies approach. Rather, the proper level of inquiry should be applied with knowledge of the strengths and limitations for each level. Perhaps as Jiang and McComas (2015) suggest, more open inquiry activities should be used sparingly to improve student motivation while devoting classroom instruction time to lower-level, more structured teacher-supported inquiry activities to ensure that students learn science content and its interconnectivity and gain insights about science that are free from misconceptions.

Students' misconceptions and alternative understandings in science have been a topic of much interest. Research has shown that misconceptions are resistant to change and can persist even with formal science instruction. Although most teachers are aware of misconceptions, they do not understand how they develop or fully appreciate their impact on instruction (Gomez-Zwiep, 2008). It is thus important for teachers to persistently probe for their students' understanding.

Probing student understanding

Teachers were asked the extent to which they provide opportunities for students to show their understanding. A variety of strategies are used by teachers to probe the development of their students' conceptual knowledge in science. These are listed in chart 6.5 in order of decreasing frequency of use by teachers. Using a wider variety of techniques to explore student understanding has a significant, positive association with higher achievement scores in science (chart 6.6).[30] Students who were allowed the greatest variety of ways to show their understanding (i.e., all seven methods) had

[30] Even though the error bars of "none" and "all the strategies" opportunities overlap, the t-test indicates that the difference is significant.

higher performance than those in classes where teachers did not allow such opportunities, even after controlling for class size and instructional methods.

CHART 6.5 **Teachers' use of a variety of opportunities for students to show understanding in science**

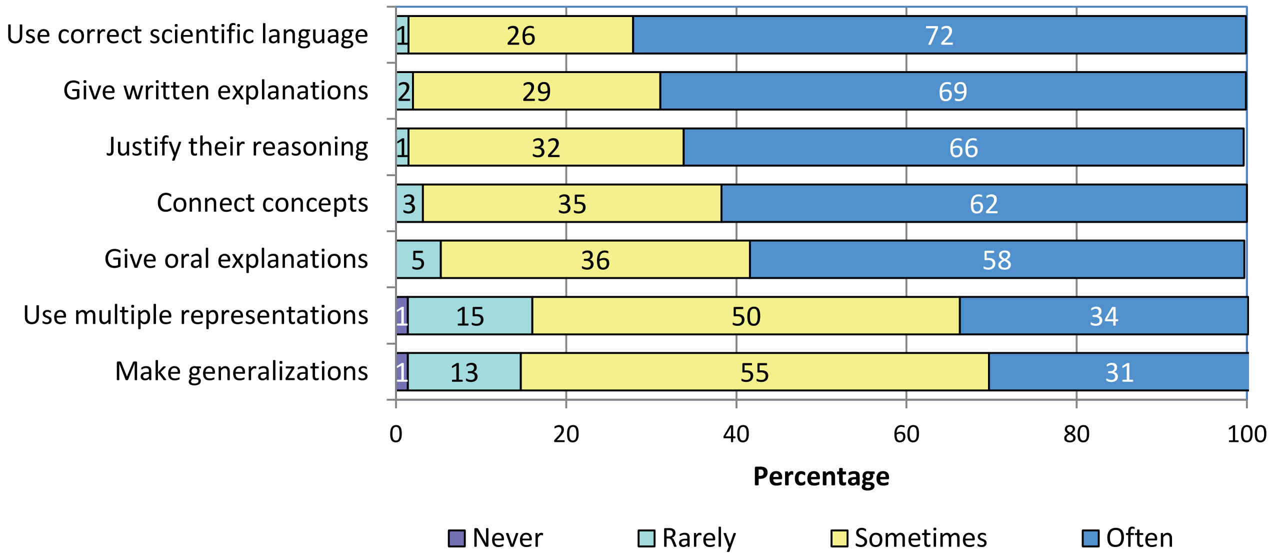
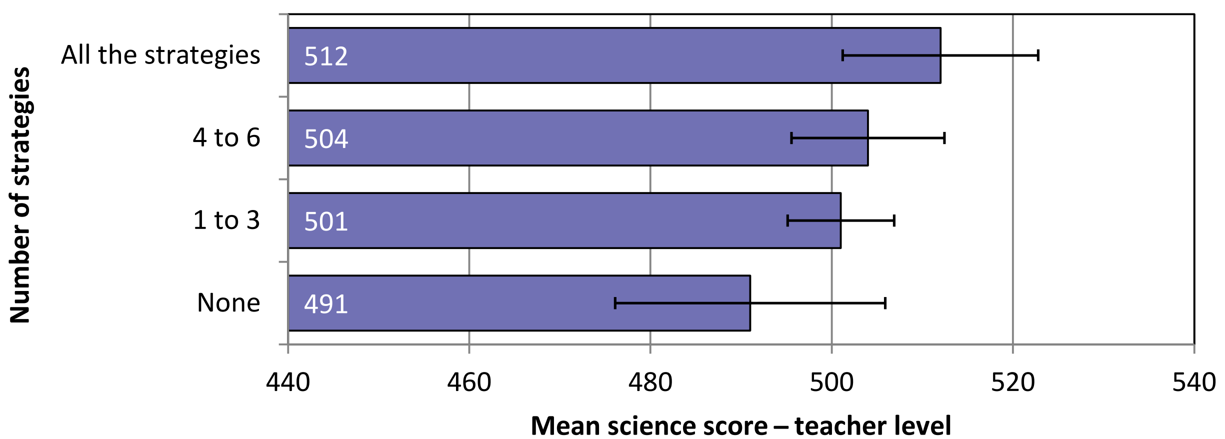


CHART 6.6 **Relationship between providing a variety of opportunities for students to show understanding and science achievement**



Meeting the needs of all students

School-wide inclusion is concerned with equity among all students. It is widely acknowledged that teachers and school systems work hard to meet the needs of all their students, including those who struggle with particular content, need an accelerated curriculum, require language enhancements, or require supports and/or services to support their learning. For the student to successfully engage with the curriculum, teachers need to identify the best instructional *situation* for the student (Sailor, 2015). The PCAP questionnaires attempted to survey the extent to which teachers used different strategies (i.e., remediation, differentiation, and enrichment) or modified their classrooms or instruction to support their students.

The purpose of these questions was not to probe classroom composition nor the strategies used with students identified with special learning needs or those involved with gifted education programs. Schools were asked to balance inclusiveness and student well-being. Although all students were to be given the opportunity to participate in this study, it was important that students with special needs not be overly pressured into participating if they would be adversely affected or if appropriate accommodations (adaptations/modifications) could not be made for them. School officials determined student exemptions based on three criteria: functional disabilities, intellectual disabilities or socioemotional conditions, and language (non-native-language speakers). Although a number of alternative formats (e.g., Braille, audio versions) were available for PCAP, students could be exempted if appropriate modifications could not be made to accommodate their specific needs.

Teachers were asked about the strategies they use in their classes to meet their students' needs. The first series of questions probe the frequency (not at all, a little, more than a little, or a lot) of teachers' use of three different teaching strategies. Technically, a composite score could be computed from these three items but such a score could be misleading because it would not account for classroom composition. High scores on all three could result in lower average achievement, especially if a large class had a greater proportion of students requiring remediation than enrichment, both of which require some form of differentiated instruction. Therefore, they were treated as separate independent variables and the independent contribution of each one was assessed. The study reports the relationship with achievement but does not infer causality or imply best practices because such conclusions would require more comprehensive, classroom-level research than is possible with large-scale assessments.

Teachers were also asked to identify the types of accommodations they use to support their students from a list of 10 strategies that were identified as being commonly used in classrooms. A single variable was then computed for the number of different modifications that each teacher uses. Finally they indicated how often an adult was present during science instruction to assist them. These variables were included in a survey-based multifactor linear model to determine their association with the science outcome.

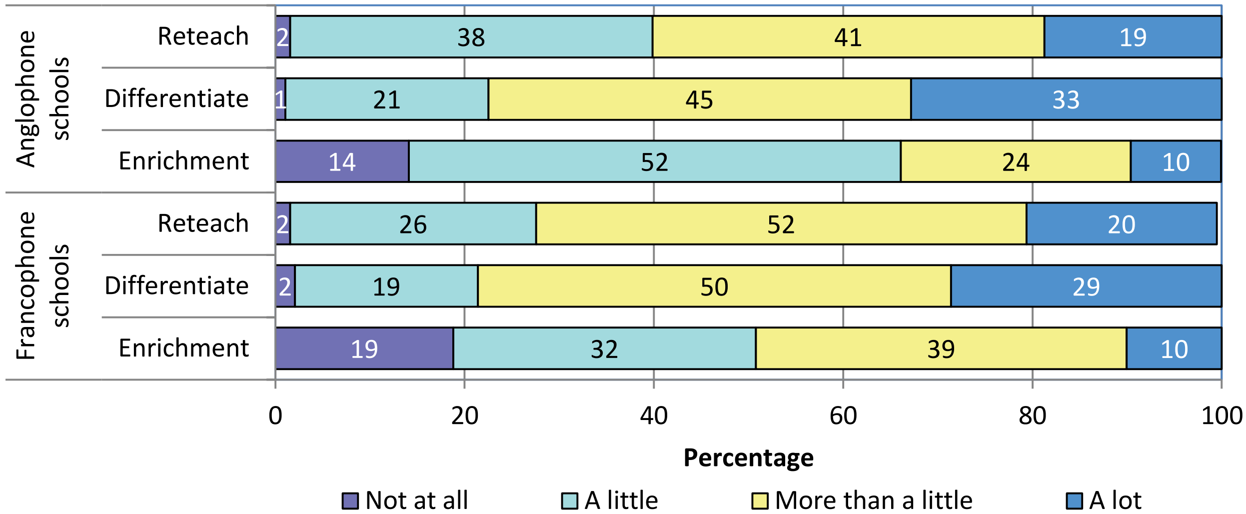
Use of teaching strategies

Teachers were asked the extent to which they use three different teaching strategies (remediation, differentiation, and enrichment) to meet the needs of all their students (table 6.2). As chart 6.7 presents, about 20 per cent of teachers report that they reteach concepts and skills "a lot" and about 30 per cent of teachers differentiate instruction "a lot." The proportions are similar for both anglophone and francophone schools. Teachers provide enrichment for their students less frequently (10 per cent). All three strategies show a significant association with science achievement.

Table 6.2 **Teaching strategies used to meet the needs of all students**

To what extent do you use the following strategies during science instruction?
Reteach concepts and skills that should have been mastered earlier.
Differentiate instruction/resources to adapt to students' learning styles, interests, and needs.
Provide enrichment for advanced students.

CHART 6.7 **Frequency of teachers' use of different strategies to accommodate students' needs**



Providing *enrichment opportunities* is positively associated with achievement. The Schoolwide Enrichment Model promotes an increase in student effort as well as enjoyment and an increase in performance (Renzulli, 2005). This approach stems from the belief that all "gifted" students should have the opportunities to develop higher-order thinking skills (Renzulli, 2005). However, as Reis and Renzulli (2003) see it, the "gifted" label should be placed on the service and not on the student. It is meant to focus on the talents of all students, not only those who fall into the "gifted" category. In her study of enrichment during regular classroom programming, Burris (2011) concluded that by providing students with enrichment activities, there are more opportunities to reach all students, even those who have a difficult time in the classroom, whether because of behaviour or learning difficulties. In addition to increased motivation, she reported that enrichment curriculum at the elementary level also "increased the students' home-to-school connection, making them more eager to share what they were doing and learning at school at home with their families, and also bringing in experiences from their own homes into the classroom" (p. 44).

According to PCAP 2013, classes where teachers provide enrichment for students at any level of frequency (a little, more than a little, or a lot), show higher average achievement than classes where the strategy is not used at all (chart 6.8). This is not surprising because enrichment studies are generally offered to students who have already mastered the basic curricular expectations.

Remediation for students who struggle with curricular content may be offered in a variety of ways: from extra assistance by classroom teachers to an extra subject period during the school day to separate programming for students. Much of the research has focused on separate remediation programs for students, particularly in mathematics, but there are few connections to the work in regular classrooms. Short-term programs, such as summer school, have been positively related with both achievement and students' self-efficacy in mathematics in middle school students (Chapman, 2013). In a study of responsive practices in middle schools, MacIver and Epstein (1992) reported that the student completion rate was higher in schools with responsive remediation programs only when the help being offered did not stigmatize, label, or separate students from their peers. The authors noted that the provision of an extra subject period during the school day was more beneficial than other approaches to remediation possibly because of higher attendance and lower stigmatization of low achievers (MacIver & Epstein, 1992). However, benefits increased by combining a variety of practices such as a student advisory program and responsive grading practices in addition to the scheduled remediation class (MacIver, 1990). In their meta-analysis of strategies that work for at-risk students, Slavin and Madden (1989) noted that "both pullouts (i.e., removing some students for extra help) and in-class models are probably too limited a change in instructional strategy to make much of a difference" (p. 6). They recommended a comprehensive approach that included an emphasis on ongoing classroom change. But classroom change must be accompanied by adequate teacher preparation and professional development which requires appropriate resources (Dill, 1993).

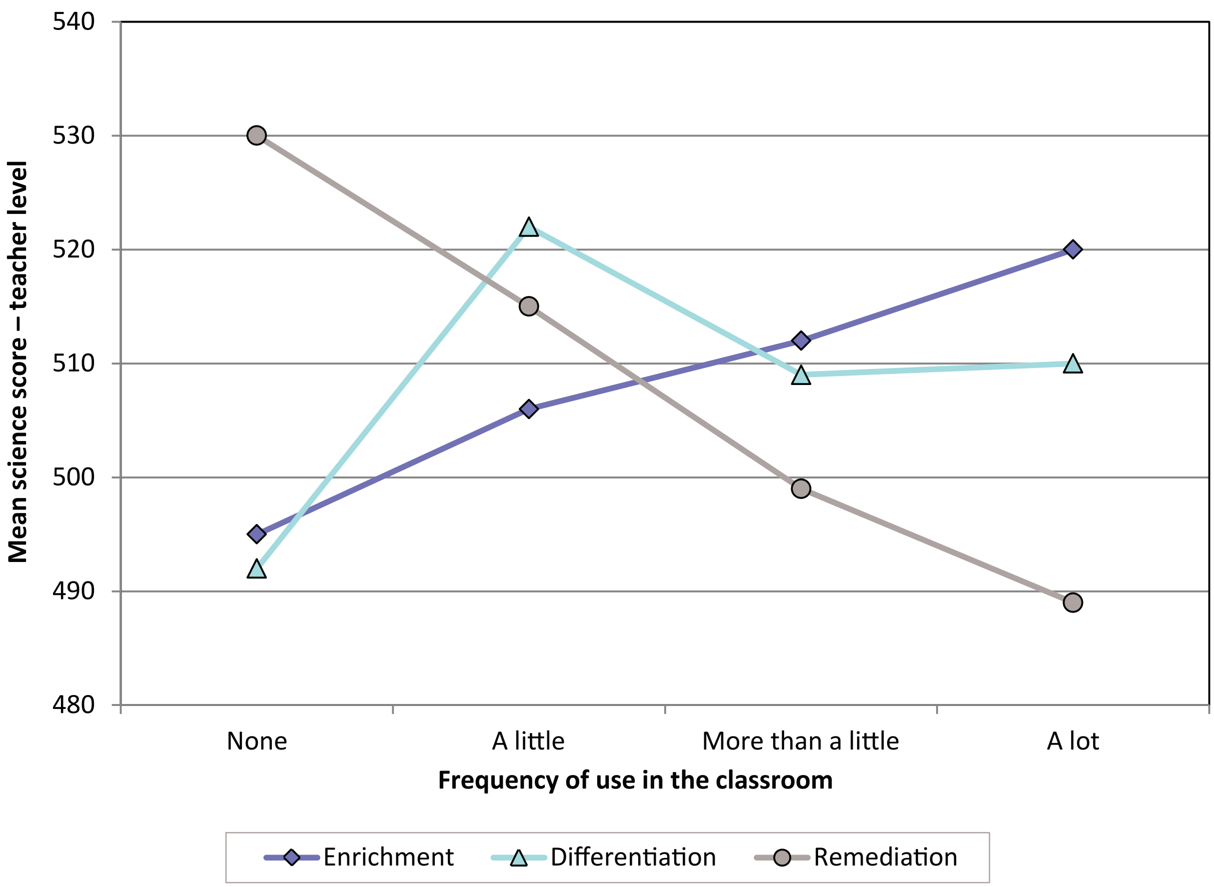
In PCAP 2013, teachers were asked to what extent (not at all, a little, more than a little, a lot) they use the strategy, "reteach concepts and skills that should have been mastered earlier." The need to *reteach concepts and skills* is negatively associated with achievement. The less teachers use this strategy, the higher their students' scores are. More specifically, the PCAP 2013 data show that in classes where the strategy is used the least frequently students have higher achievement than in classes where more frequent use of remediation (more than a little or a lot) is required (chart 6.8). There was no attempt to account for classroom composition with this question and so, for example, teachers who responded that they use remediation strategies may have been referring to their use with a few students or with their entire class. This may imply that teachers who report the need to use remediation a lot may be teaching in classrooms with a higher proportion of students who are struggling to master basic curricular expectation.

The differentiated instruction model rethinks the structure and management of the classroom so that students become more engaged with the process. Almost 80 per cent of teachers reported that they provide *differentiated instruction* for the students either "a lot" or "more than a little." However, students taught by these teachers tend to achieve lower scores than students in classes where this strategy is used less frequently (chart 6.8). Blozowich (2001, cited in Subban, 2006) suggests that although teachers may use a variety of techniques to provide for academic diversity, they continue to prepare lessons as they would for a tracked (or streamed) classroom with lessons of varying difficulty being offered but without focusing on variation in student learning styles and interests. In Affholder's (2003, cited in Subban, 2006) investigation of instruction strategies that teachers employ, the author concluded that teachers who used differentiation strategies more intensively were more responsive to their students' needs but that extensive training in the techniques and experience with the curriculum were important factors for the successful adoption of the model.

Although 90 per cent of teachers reported that their PD activities on differentiating instruction/resources had an effect on their students' learning to some level (i.e., some or a lot), this type of PD had no significant impact on achievement in science. Time available for PD is an important resource with many competing priorities and so it seems unlikely that school districts could devote enough PD time for the extensive training required for the successful use of this model, as Affholder's study (Subban, 2006) reports. With contemporary classrooms becoming increasingly diverse, school districts, teachers, and school administrators are looking to teaching and learning strategies to address learner variance. The inclusion of students from non-English-speaking backgrounds, students with disabilities, students from diverse cultural backgrounds, and students on accelerated programs compel educators to re-examine their teaching and instructional practices (Subban, 2006).

The PCAP results suggest that although some differentiation leads to an improvement in student achievement, there are diminishing returns with increasing use of this strategy (chart 6.8). It is important to note that the relationship with student achievement does not assess the efficacy of using different teaching practices, but rather reflects the fact that teachers work in classrooms made up of students with a wide range of abilities and needs. For example, if the number of students requiring remediation is high the performance of students in such classes may be anticipated to be weaker. It is not the use of these tools that produces lower performance but that teachers strive to meet all their students' needs — teachers use these tools because of who the students are in their classroom. Classroom-level research would be required to determine whether different teaching strategies were being focused at specific groups of students. For example, reteaching or enrichment may be considered differentiation strategies in a classroom context when used to support the variety of learning styles and student needs across Canada.

CHART 6.8 **Relationship between the use of teaching strategies and science achievement**



Use of accommodations, adaptations, or modifications

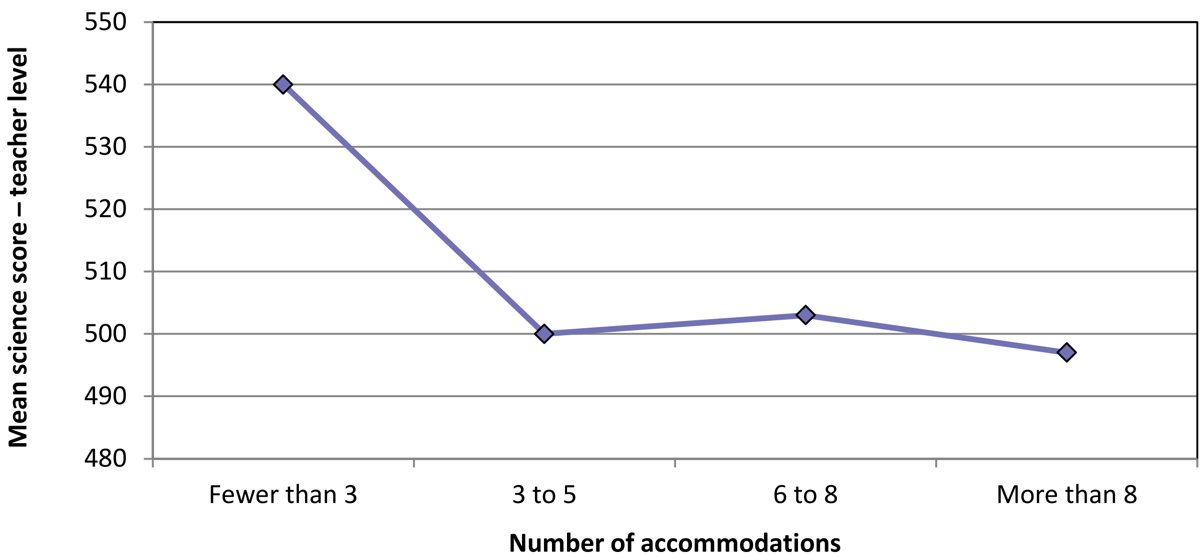
Meeting all students' needs is a growing priority for ministries of education across the country. Teachers meet the needs of their students in a wide variety of ways, including help from other professionals and modifying lessons and resources to accommodate the variety of needs they encounter. Teachers were asked about their use of 10 accommodations being used in classrooms. The list was not intended to be exhaustive and there was no attempt to link this information to specific classroom composition, but it serves to probe the variety of ways the teachers strive to support their students. As table 6.3 shows, the two most frequently reported modifications are allowing more time to accomplish a task (98 per cent) and adapting teaching methods (94 per cent) for their students.

Table 6.3 **Percentage of teachers meeting student needs with accommodations**

Have you met the needs of your students with the following accommodations (adaptations), or modifications?	Yes (%)
More time in which to accomplish a task	98
Adapted teaching methods	94
Program modifications (e.g., alter course expectations)	81
Special assistance with speaking, listening, reading, or writing	73
Assistive technologies	63
Help of an education assistant (e.g., teaching aide, interpreter)	61
Medical attention	31
Withdrawal of student from science class (assignment to a special class)	31
Help of a medical assistant (e.g., counsellor, speech pathologist, therapist)	30
Help of a lab assistant	23

The need to provide an increasing variety of modifications for students has a much greater impact on student achievement. Higher science scores are found in classrooms in which teachers report making fewer than three different types of modifications for their students compared to classrooms requiring an increasing variety of adaptations to meet students' needs (chart 6.9). This relationship does *not* imply causality. The profile of the classroom would be an important component when interpreting the data and, although this could be explored through classroom-level research, it is beyond the scope of large-scale assessment.

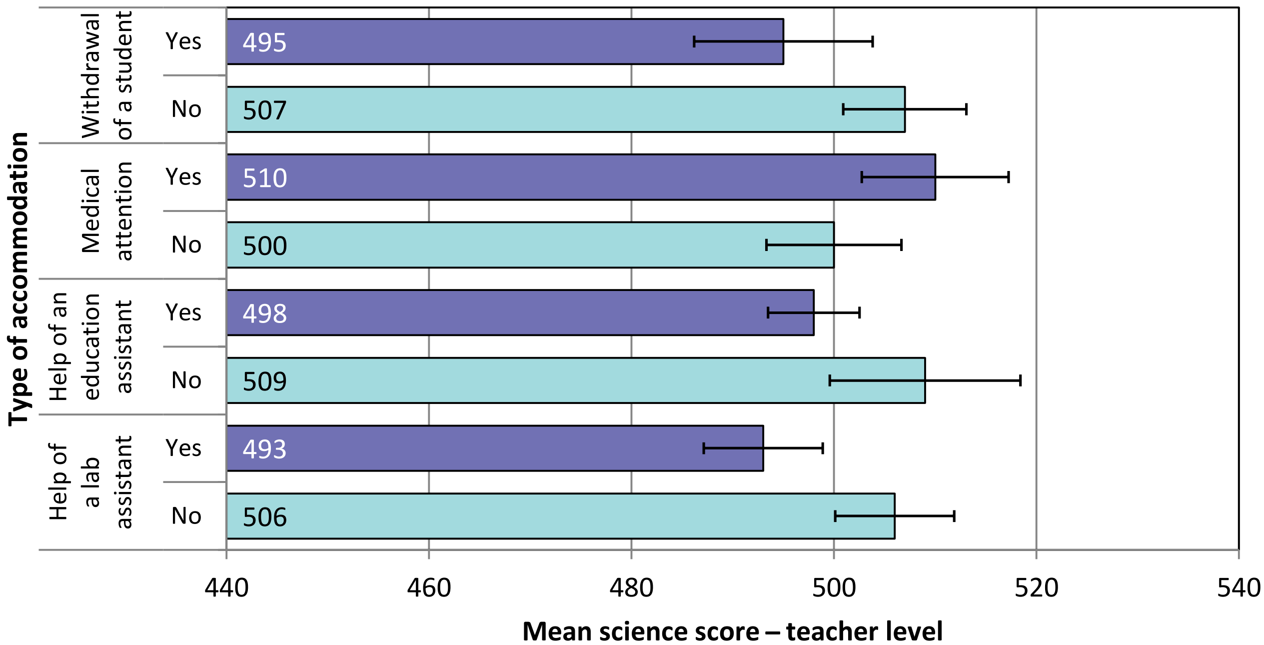
Chart 6.9 **Relationship between the number of accommodations used in classrooms and science achievement**



Further analyses were conducted at the individual accommodation level. The results show that only half of the 10 accommodations listed have a significant impact on achievement, and of these five, only one — meeting student needs with medical attention — had a positive impact (see chart 6.10).

Additional time is not reported in the chart. Because the vast majority of teachers report that they use this modification the small number who do not report using it causes large confidence intervals to be associated with this measure.

CHART 6.10 **Relationship between the use of accommodations and science achievement**[31]



The requirement to modify instructional practices or the classroom environment could stem from a variety of student or teacher needs. For example, a lab assistant may be required in large classes or education assistants may be provided for students with emotional, behavioural, or learning difficulties. More complex statistical analysis may uncover further relationships between student, teacher, and school characteristics that would show how schools are successful in providing an environment that encourages their students' academic and social development while providing a safe and supportive environment.

Presence of another adult

Another adult may be in a science classroom to provide an accommodation for a student or additional supervision for hands-on tasks such as laboratory activities. Twenty per cent or more of teachers report that another adult is present in the science classroom "most or all" of the time in anglophone schools in Manitoba and New Brunswick and in francophone schools in Saskatchewan and New Brunswick (chart 6.11). As chart 6.12 shows, the presence of other adults in the classroom is negatively associated with achievement when they are present up to one-half, most, or all of the time compared to those classrooms that never require an additional adult. This may suggest that classrooms requiring an additional adult may have more students with behavioural or academic challenges although further research would be needed within jurisdictions to answer this question.

[31] Even though the error bars overlap, the t-test indicates that the difference is significant.

CHART 6.11 **Frequency of the presence of another adult in the science classroom**

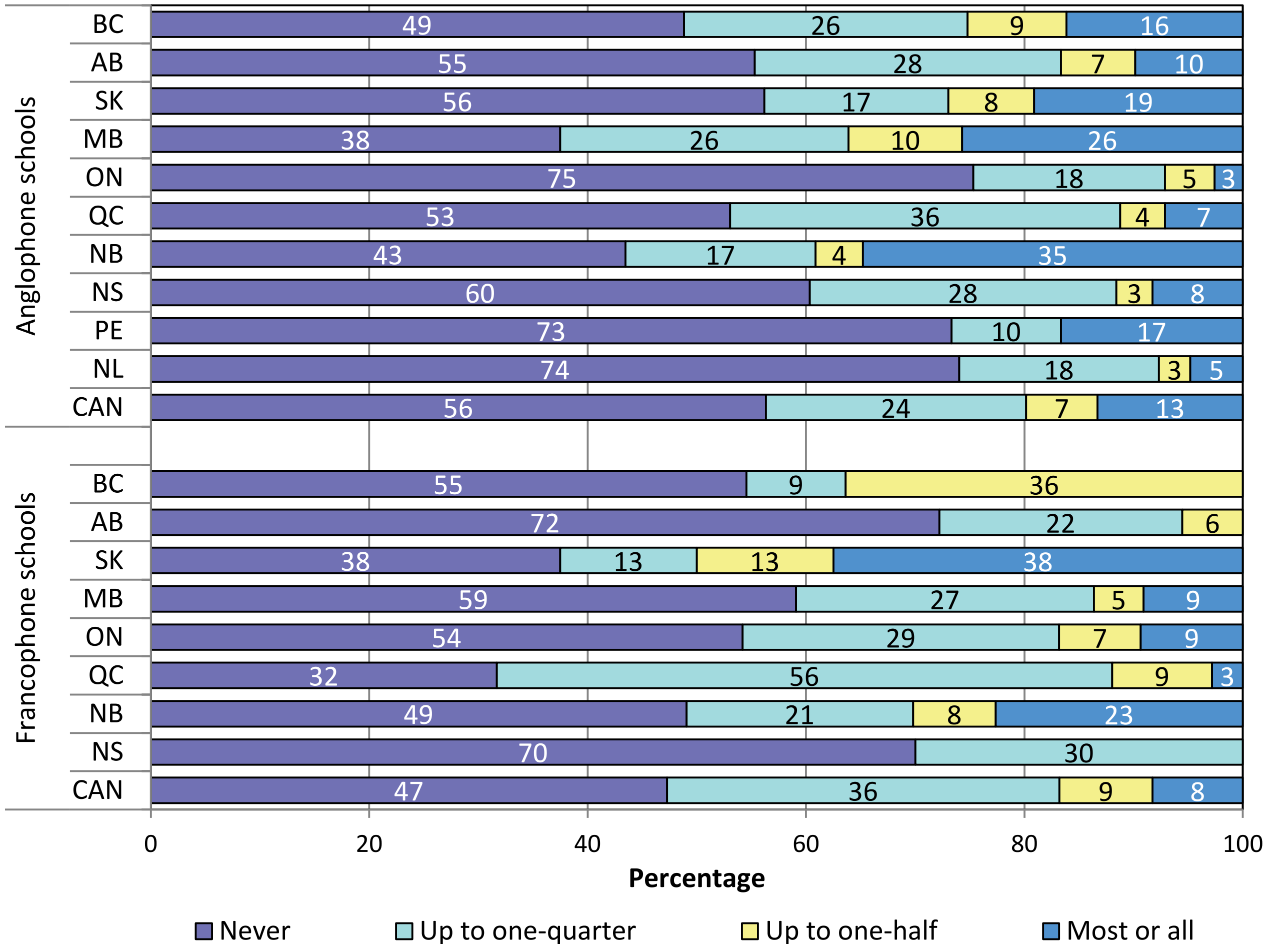
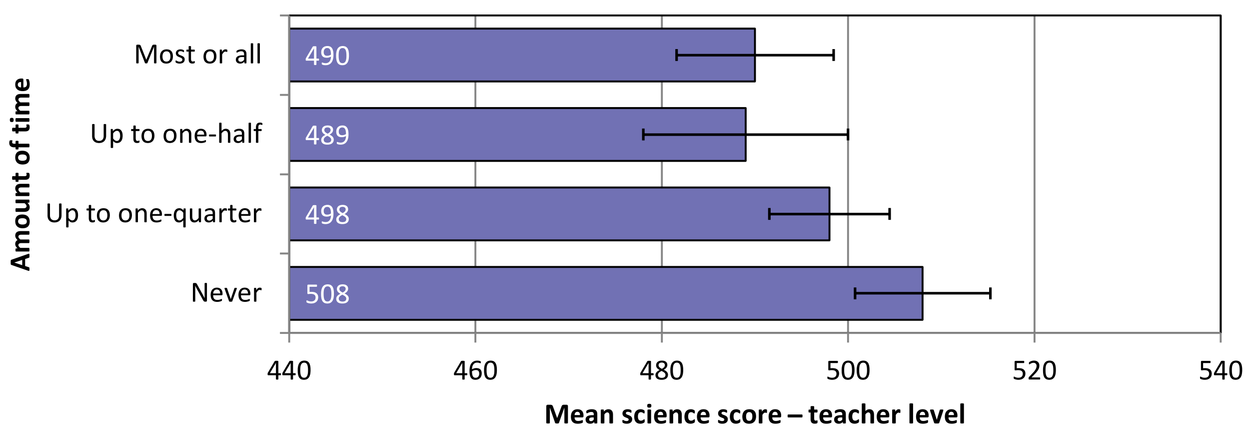


CHART 6.12 **Relationship between the amount of time another adult is in the classroom and science achievement**



Teacher absenteeism

Absenteeism in Canada contributes to a substantial loss in productivity. In business, the loss is economic but in education, the greater cost may be related to student achievement. The average absenteeism rate in Canada was 9.4 days per full-time employee in the education sector in 2011 and often, the more generous the sick leave policy, the greater the rate of absenteeism (Stewart, 2013). Herrmann and Rockoff (2010) analyzed data spanning 10 years from a large US school district. They found that there was a greater impact on achievement with higher absenteeism for more experienced teachers and argued that this is related to the increased productivity or effectiveness of more experienced teachers. The study, which focused on math and English teachers in Grade 4 and 8, concluded that a more important parameter than the number of days absent was the timing of absences: there were larger effects found for absences in the days or weeks leading up to exams.

Teachers were asked how many days their class was taught by someone other than themselves (e.g., by a substitute teacher). Teachers in British Columbia and francophone teachers in Saskatchewan and Quebec report the lowest frequency of having another teacher in their classrooms (five or fewer days), whereas francophone teachers in Nova Scotia report the highest frequency (20 or more days) as chart 6.13 indicates. The data show a non-linear relationship with achievement. Students in classrooms in which their teacher is absent between 10 and 19 days show the lowest achievement compared to the other three categories which are not significantly different from each other (chart 6.14). Although it is surprising that longer teacher absences may have limited impact on student achievement, this may be because substitute teachers are becoming more productive on the job or administrators may be seeking out more productive (or experienced) teachers for extended job assignments (Herrmann & Rockoff, 2010).

CHART 6.13 **Number of days that a teacher's class is taught by someone other than themselves**

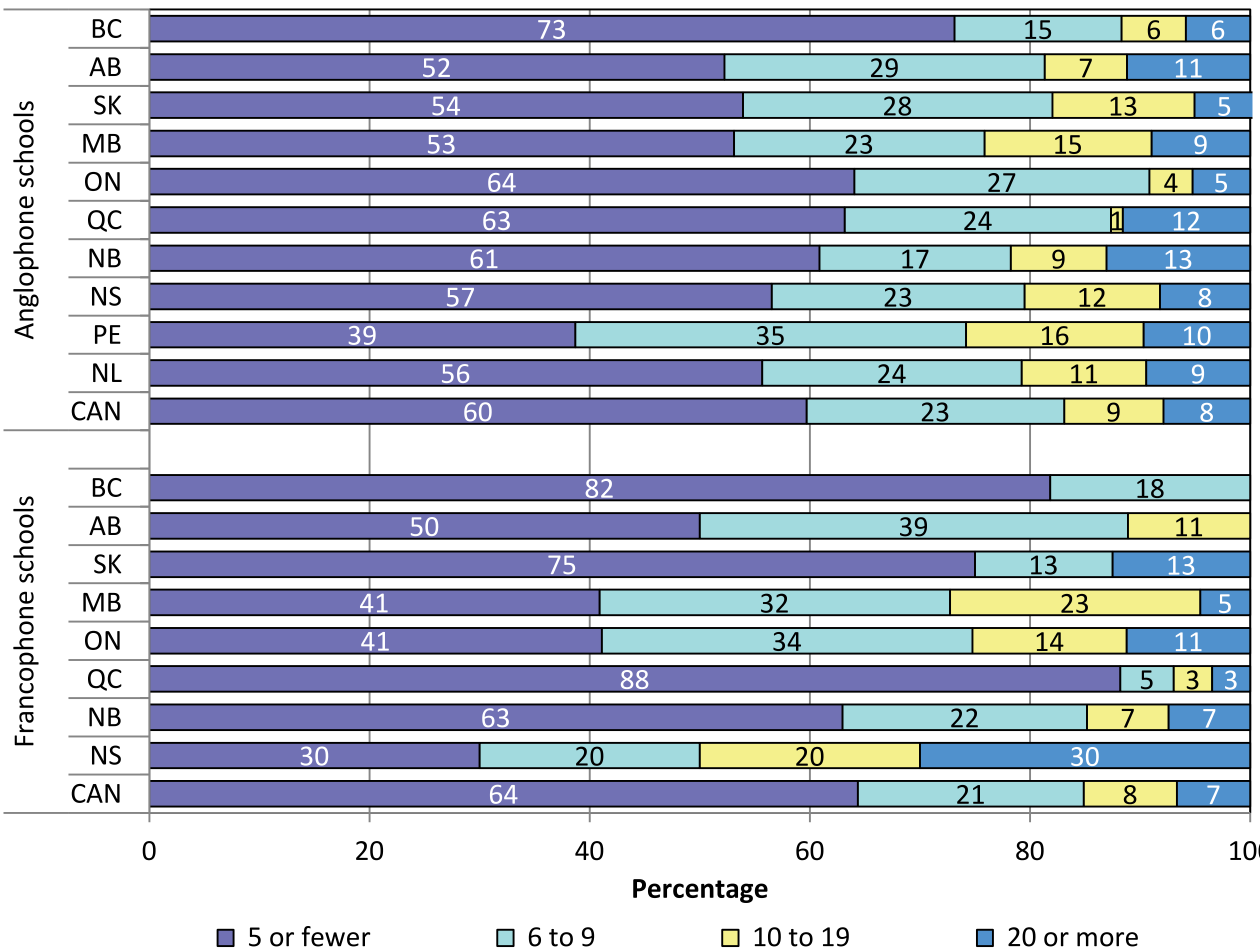
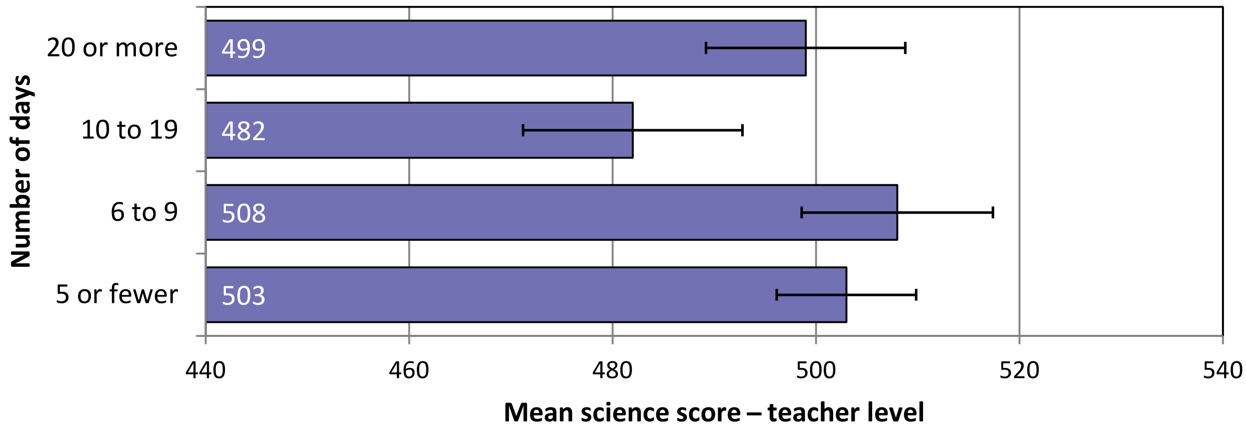


CHART 6.14 **Relationship between the number of days a teacher is replaced in their classroom and achievement in science**



Challenges in teaching science

Teachers responded to a series of 22 questions on the challenges they face in teaching science using a four-point scale from "no challenge" to "a great challenge." These resulted in three factors that appear in table 6.4. For each factor, the items are ordered by the decreasing frequency by which teachers report that the items present "a great challenge" to their teaching. Of these three factors, only the combination of challenges that make up the student-related factor prove to have a significant relationship with science achievement. The two student-related challenges reported most frequently as challenging teachers' ability to teach science are the range of student abilities in the class and uninterested students. As charts 6.15 and 6.16 show, these factors present some challenge or a great challenge to approximately 80 per cent of teachers in most jurisdictions. In francophone schools, a higher proportion of teachers report that these factors present little or no challenge compared to anglophone schools. It is troubling to note that almost 50 per cent of teachers identify that concerns for the safety of themselves or their students present at least some level of challenge to their teaching (chart 6.15). Indeed, more than 20 per cent of anglophone teachers in New Brunswick and francophone teachers in Quebec report that concerns for personal safety or the safety of students present "some challenge" or "a great challenge" to their ability to teach science (chart 6.18).

Table 6.4 **Challenges to science teaching reported by teachers**

Factors	To what extent do the following present challenges to your ability to teach science?
	Negative relationship with achievement
Student-related challenges	The range of student abilities in the class
	Uninterested students
	Large class sizes
	Disruptive students
	Students coming from a wide variety of backgrounds (e.g., socioeconomic, linguistic, cultural, etc.)
	Low morale in the school
	Concerns for personal safety or the safety of students
	Pressure from parents/guardians
	No significant relationship with achievement
Resource challenges	Shortage of equipment (e.g., microscopes, glassware)
	Inadequate physical facilities
	Shortage of consumable materials
	Shortage of computer hardware or software
	Inadequate resources for lesson planning
	Inadequate Internet access
Teacher and program challenges	Too much content in curriculum
	Lack of time for planning
	Too few instructional minutes assigned to science
	Lack of professional development
	Inadequate resources for lesson planning
	Inadequate collegial support
	External assessments or standardized tests
	Limitations in the subject in my own background
	Curriculum inappropriate for grade level

CHART 6.15 **Student-related challenges that affect achievement in science**

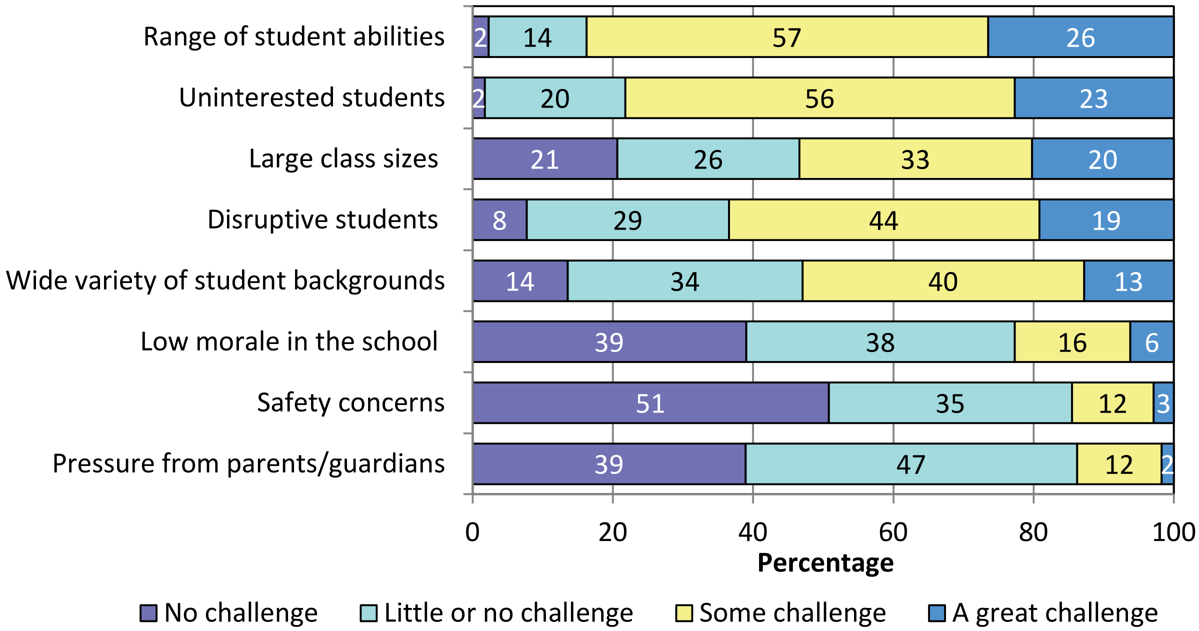


CHART 6.16 **Distribution of teachers reporting that the range of student abilities in their classroom challenges their teaching**

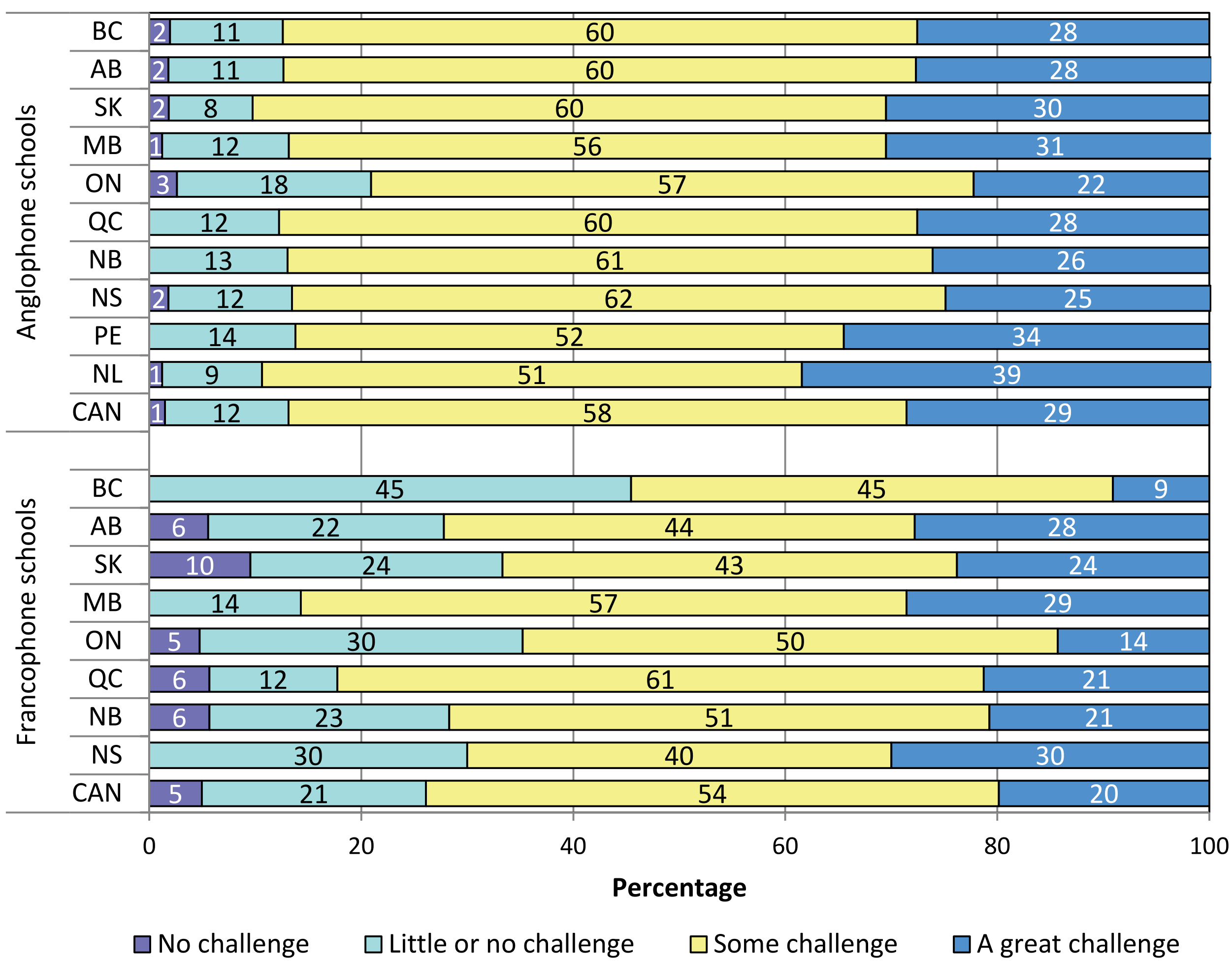


CHART 6.17 **Distribution of teachers reporting that uninterested students challenge their teaching**

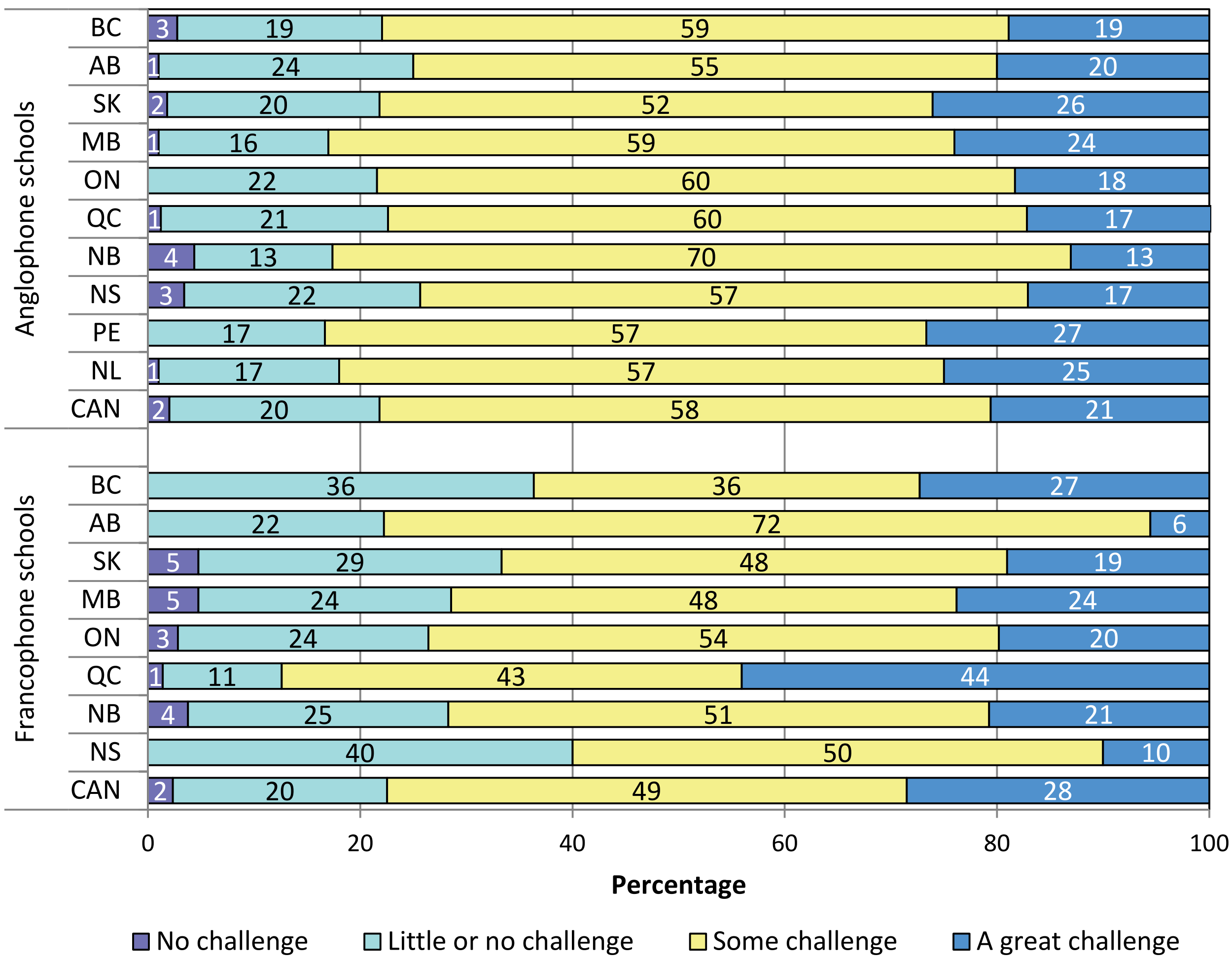
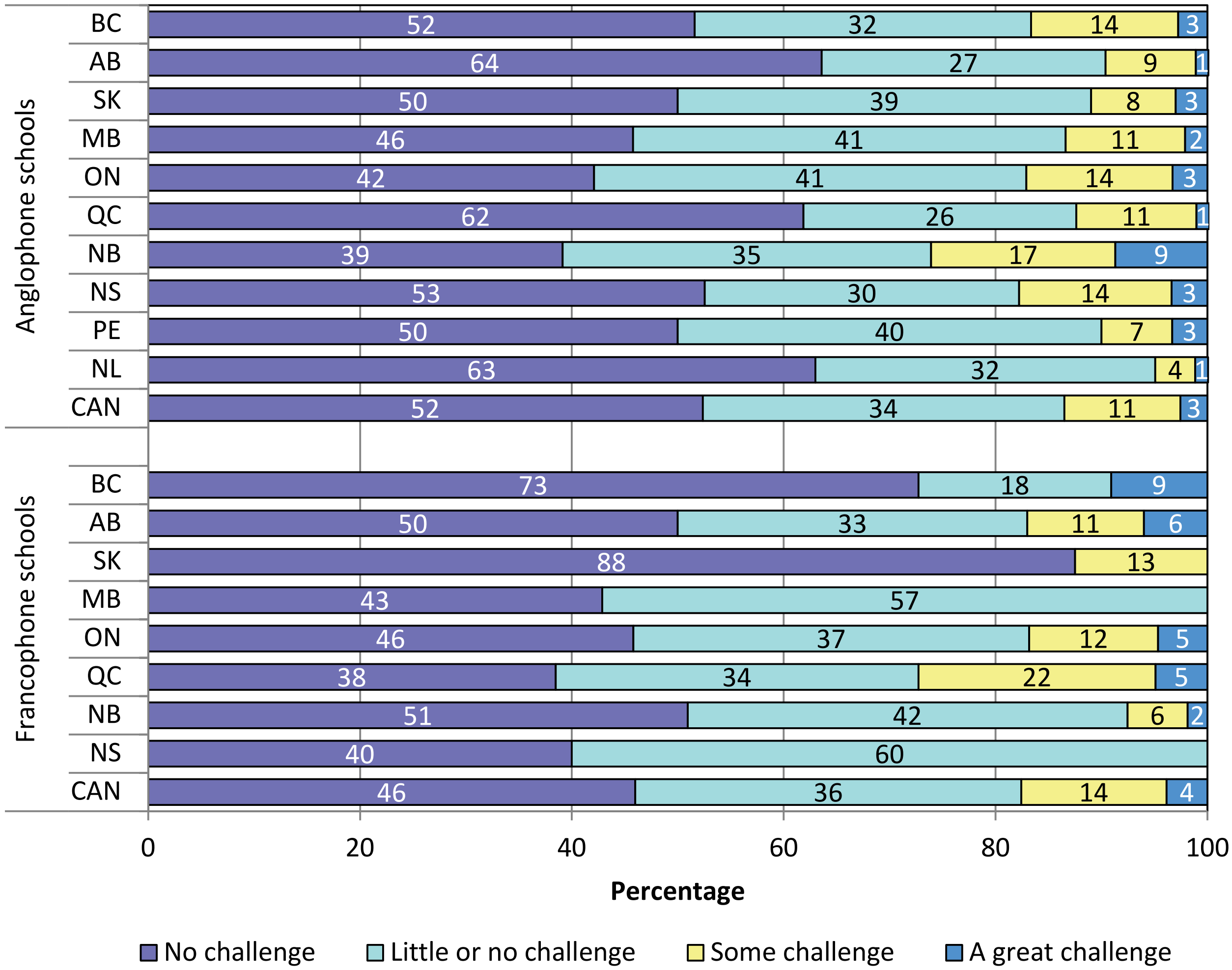


CHART 6.18 **Distribution of teachers with safety concerns that challenge their teaching**



Teaching self-efficacy

Teachers' sense of efficacy — the belief that they can have a positive effect on student learning — has emerged as an important construct in teacher education over the past 25 years. Teacher efficacy is grounded in Bandura's social cognitive theory (1977; 1997), which roots human agency in a sense of self-efficacy. According to Bandura, self-efficacy beliefs motivate people toward specific actions in all aspects of their lives, and therefore have predictive value. Bandura identified two dimensions of self-efficacy: personal self-efficacy and outcome expectancy. When applied to teaching, the self-efficacy factor is generally known as Personal Teaching Efficacy (PTE). Teachers with a high level of PTE have confidence that their training or experience will allow them to help their students overcome obstacles to their learning (Bandura, 1977). The second factor, when applied to teaching, is commonly called General Teaching Efficacy (GTE) and is related to teachers' belief that they can influence a student's motivation and performance.

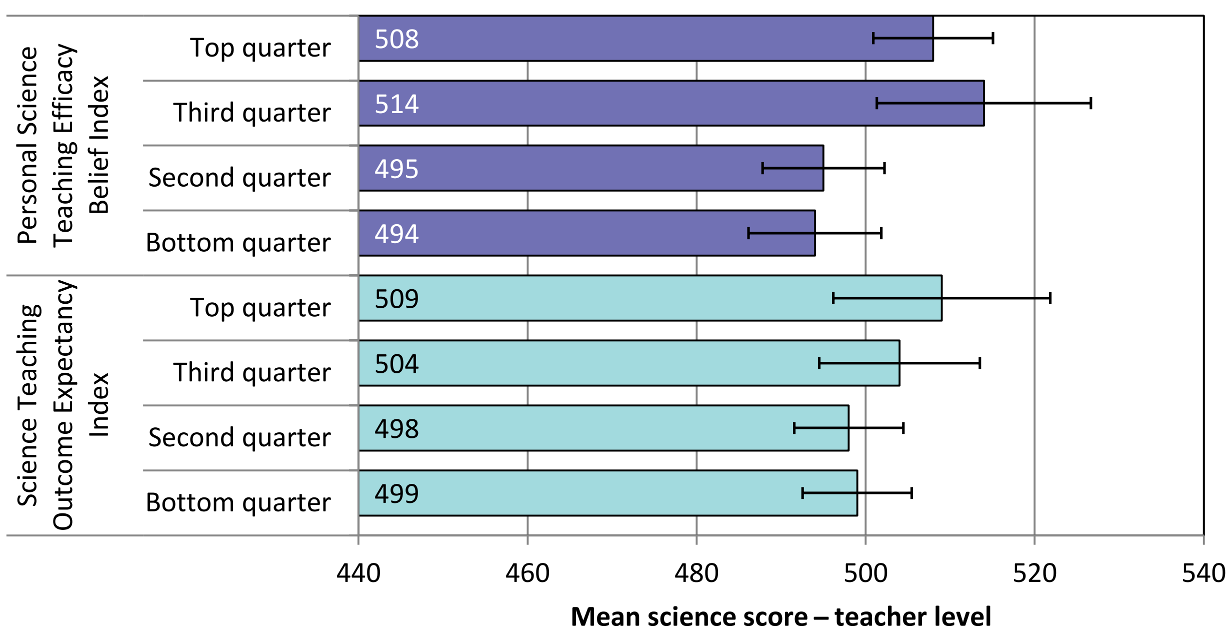
To examine the relationship between student achievement and teaching efficacy, teachers completed the Riggs and Enochs (1990) *Science Teaching Efficacy Belief Instrument*. This instrument was developed to explore the added dimension of the specific teaching situation's impact on teachers' efficacy beliefs. According to the survey developers, “teachers’ overall level of self-efficacy may not accurately reflect their beliefs about their ability to affect science learning” because by its very nature, self-efficacy is a situation-specific construct (Bandura, 1981).

The academic literature describes the validation of the Riggs and Enochs (1990) instrument. Two scales are identified: the Personal Science Teaching Efficacy Belief scale and the Science Teaching Outcome Expectancy scale. Both are similar to the PTE and GTE factors described earlier but specific to teaching science. A science teacher with high personal teaching efficacy believes that their ability to bring about change in their students’ achievement is not limited by external factors, such as the students’ home environment, whereas a teacher with high outcome expectancy believes that student improvement is related to the teacher’s own ability to use effective teaching strategies. As Gibson and Dembo (1984) predict, when both personal efficacy and outcome expectancy are applied to teaching, then “teachers who believe student learning can be influenced by effective teaching, and who also have confidence in their own teaching abilities, should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning” (p. 570).

In PCAP 2013, only the Personal Science Teaching Efficacy Belief scale proved to be a significant predictor of student achievement in science. Student scores are significantly higher in classrooms with teachers who have high scores for this scale (chart 6.19) at both the student and classroom level. Thus teachers who believe that they are good science teachers and that they can positively influence student outcomes have higher classroom scores in science.

Teacher efficacy is multidimensional, consisting of at least the two dimensions described using the Riggs and Enochs (1990) instrument. Other dimensions have also been identified, such as verbal ability and flexibility (Gibson & Dembo, 1984), which speaks to the complexity of a teacher’s role. The development of effective teachers may be related not only to their pre-service training, but also to their in-service experiences related to professional development, involvement in supportive communities of practice, and the school culture in which they work.

CHART 6.19 **Relationship between science teaching efficacy beliefs and science achievement**



Summary

This chapter examined teachers' instructional practices and beliefs and their relationship with achievement in science. According to PCAP 2013, higher classroom scores in science are associated with teachers who believe that they are good science teachers and that they can positively influence student outcomes, regardless of whether or not the student comes from a background that fosters success in school. Higher science achievement is also associated with teachers who have a large number of students in their class, often use hands-on and collaborative activities (teacher-supported inquiry strategies), and allow their students to express their understanding in a variety of ways. Higher scores are found in classes that offer some enrichment and differentiated instruction and in which there are fewer student accommodations required to meet the needs of all students.

7 TIME MANAGEMENT

Classroom learning is considered to be the core of student learning. While jurisdictions' curricular policies and school resources often set the tone for learning, students' day-to-day classroom activities are likely to have a considerable impact on their science learning. Whether time spent on subjects is determined at the jurisdiction or school board levels, the total amount of time is fixed. Scheduling learning time is affected by many competing demands and trade-offs not only during school hours but also outside of school. Thus time allocated to learning is a resource that must be efficiently and effectively managed. Students are engaged in learning not only inside the classroom but also as they engage in activities outside of school including homework, sports, and social interactions. To explore issues surrounding time management in schools, the PCAP questionnaires asked about aspects of time management of students, teachers, and school principals.

This chapter addresses learning time, the amount of homework assigned by teachers and the homework effort invested by students, extended learning time, and the loss of learning time resulting from disruptions and student absenteeism.

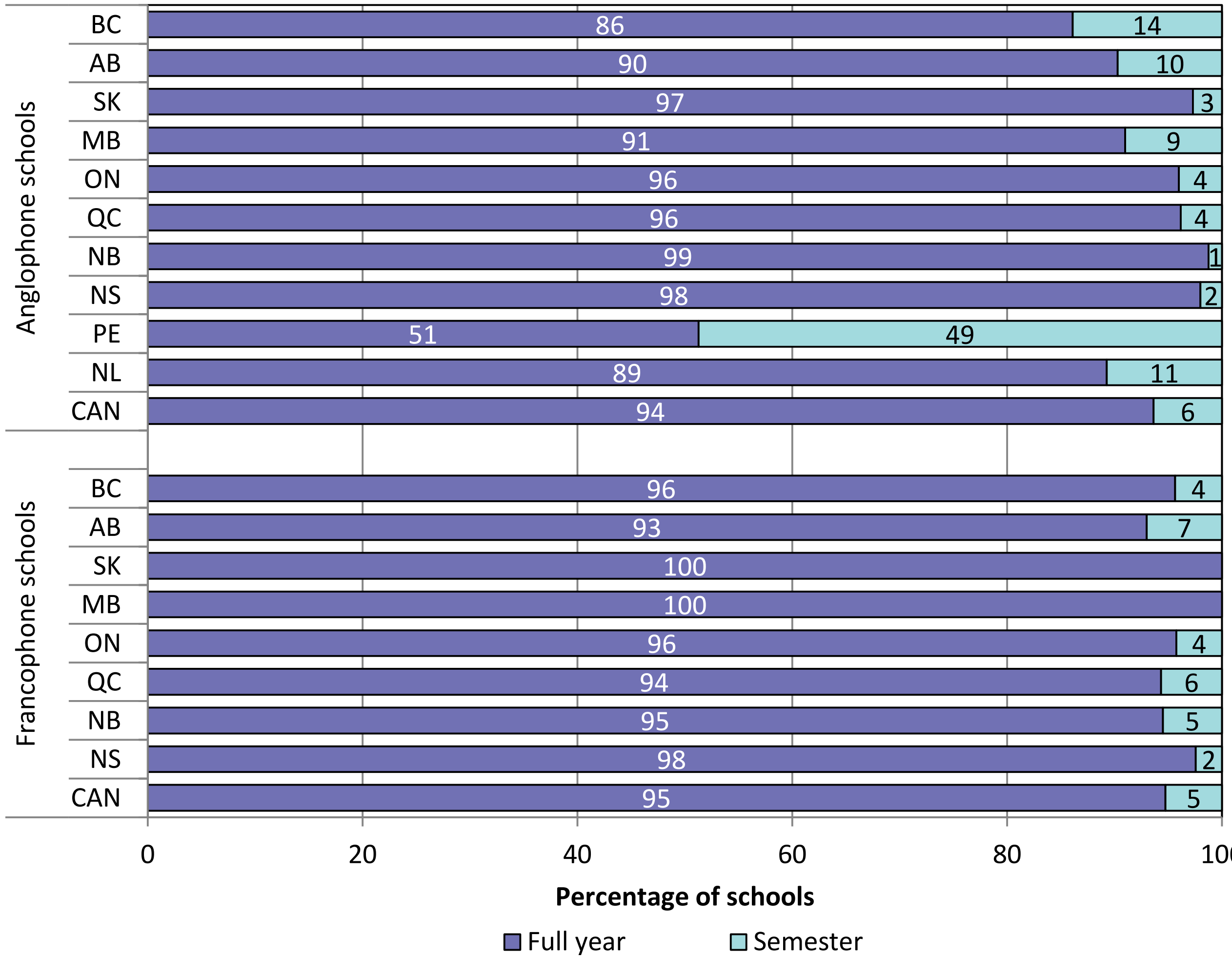
Student learning time

The relationship between instructional time and student achievement is influenced by a wide variety of factors including the curriculum, instructional approaches, and student engagement and motivation. It is difficult to develop precise measures because the amount of time actually spent in instructional tasks and the efficiency of instruction is difficult to determine (Baker et al., 2004). Recent research on instructional time generally supports the notion that additional time results in higher achievement. However, because of the difficulty in isolating variation caused by factors that affect students outside school, researchers question the strength of much of the evidence (e.g., Coates, 2003; Kuehn & Landeras, 2012; Lavy, 2010, 2012; Mandel & Sussmuth, 2011). Despite the difficulty in studying its effects, instructional time remains important when considering students' opportunity to learn and the effect of learning time on achievement.

Principals were asked a series of questions on how science is scheduled in their schools on a yearly and weekly basis. They first reported whether Grade 8/Secondary II science classes were scheduled by semester or on a full-year basis. As chart 7.1 indicates, the vast majority of schools sampled in PCAP offer full-year science programs.[32] Schools in both language systems in Nova Scotia, anglophone schools in New Brunswick, and francophone schools in Saskatchewan and Manitoba offer the highest proportion of full-year courses, whereas Prince Edward Island schools offer the highest proportion of semester courses in science.

[32] Totals may not sum to exactly 100 per cent because of rounding.

CHART 7.1 **Yearly schedule for science classes**



Principals were asked to report the number of *minutes per week* scheduled for science instruction for Grade 8/Secondary II classes. Although this scheduled time varied widely, principals' estimates clustered around several modal points such as 200 or 300 minutes. The estimates are divided into four categories for ease of presentation and consistency with the PCAP study in 2010. The highest proportion of schools offering 300 or more minutes (e.g., on average at least one hour per day) of weekly science instruction are found in Prince Edward Island (39 per cent, chart 7.2) which also has the highest proportion of semester classes for science at this level. Over 80 per cent of schools schedule fewer than 200 minutes per week in science in anglophone schools in Saskatchewan and francophone schools in Ontario. However, there is no significant relationship between achievement and the varying amount of time scheduled for science (chart 7.3). This is quite different from the scheduling of mathematics reported in PCAP 2010 in which fewer than 50 per cent of schools (from 1 to 46 per cent) in all populations reported 200 minutes or fewer per week and higher scores were associated with schools offering between 201 and 250 minutes of mathematics each week (CMEC, 2012). Although five categories (two additional categories above 300 minutes) were used for time in the PCAP 2007 assessment of reading, the general pattern showed scores declining as larger amounts of time were spent on language arts. Schools with times longer than 330 minutes per week scheduled for language arts showed significantly lower reading scores than those where students spend 200 minutes or less per week on this subject (CMEC, 2009).

CHART 7.2 **Average number of minutes scheduled weekly for science instruction**

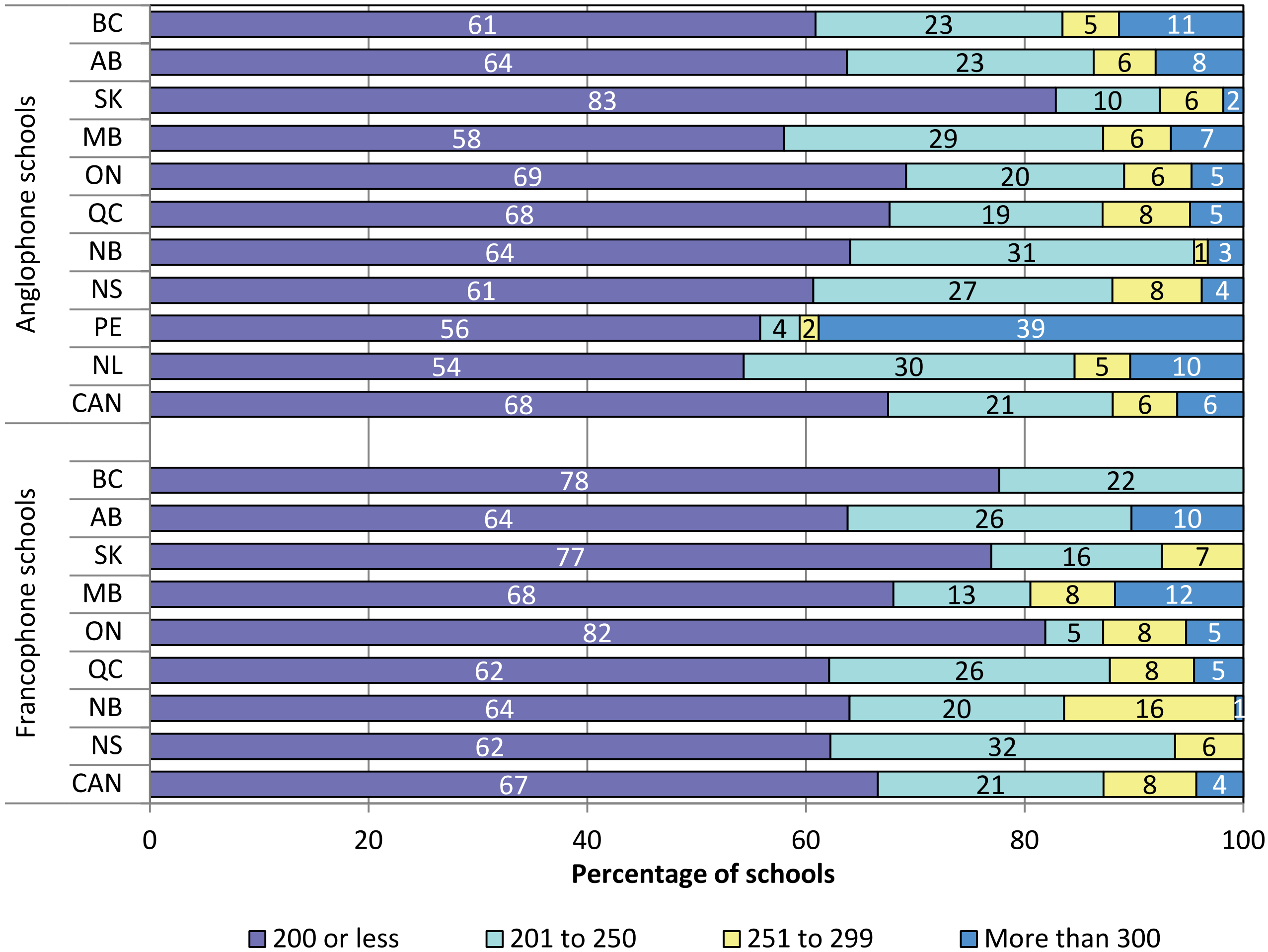
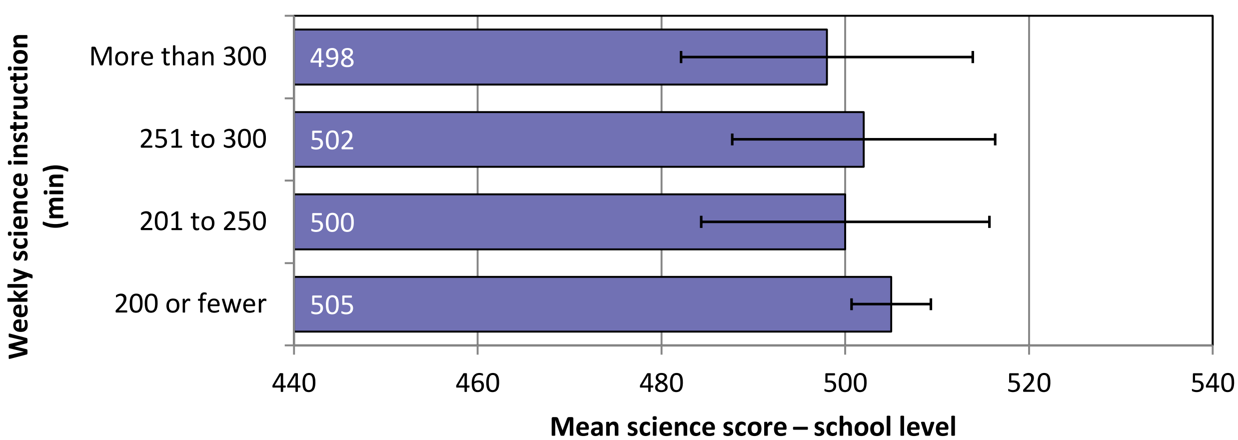


CHART 7.3 **Relationship between weekly instruction time and science achievement**



Principals reported the number of minutes scheduled for an average science class and this also varied widely between schools and jurisdictions. Class periods ranging from less than 30 minutes to more than 150 minutes were reported with the majority of schools reporting science classes scheduled between 30 minutes and 90 minutes. The highest proportion of shorter classes (40 minutes or less) is in anglophone schools in Quebec and francophone schools in British Columbia, while the highest proportion of longer classes (more than 75 minutes) is in Prince Edward Island schools (chart 7.4). Class length is not significantly related to science achievement as chart 7.5 shows. This is contrary to the results for mathematics in PCAP 2010 where classes of more than 75 minutes achieved much lower scores (CMEC, 2012). The effect of class period length on reading scores was non-linear in PCAP 2007 with the shortest (40 minutes or less) and longest (more than 60 minutes) class periods being associated with higher achievement (CMEC, 2009).

CHART 7.4 **Average number of minutes per class scheduled for science instruction**

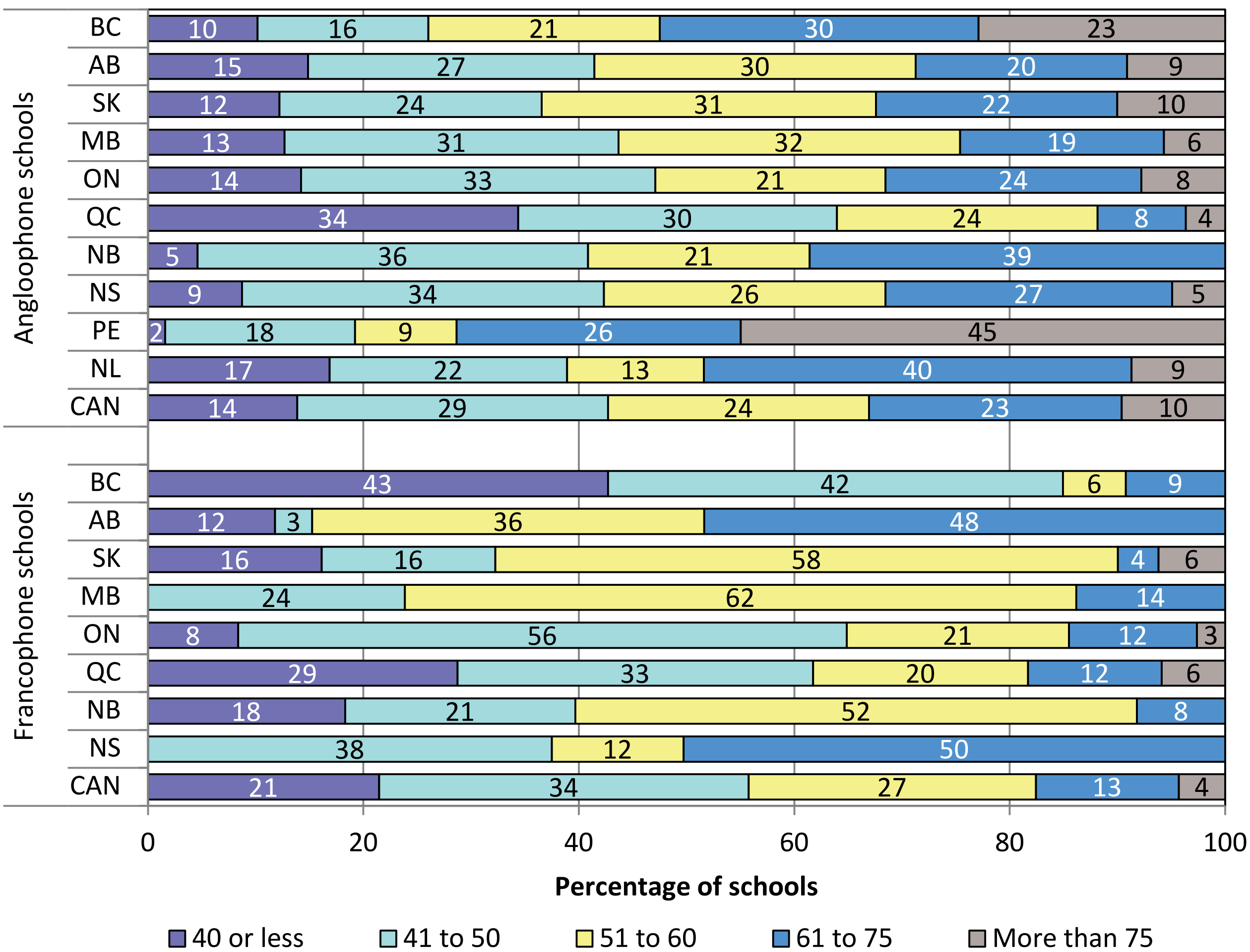
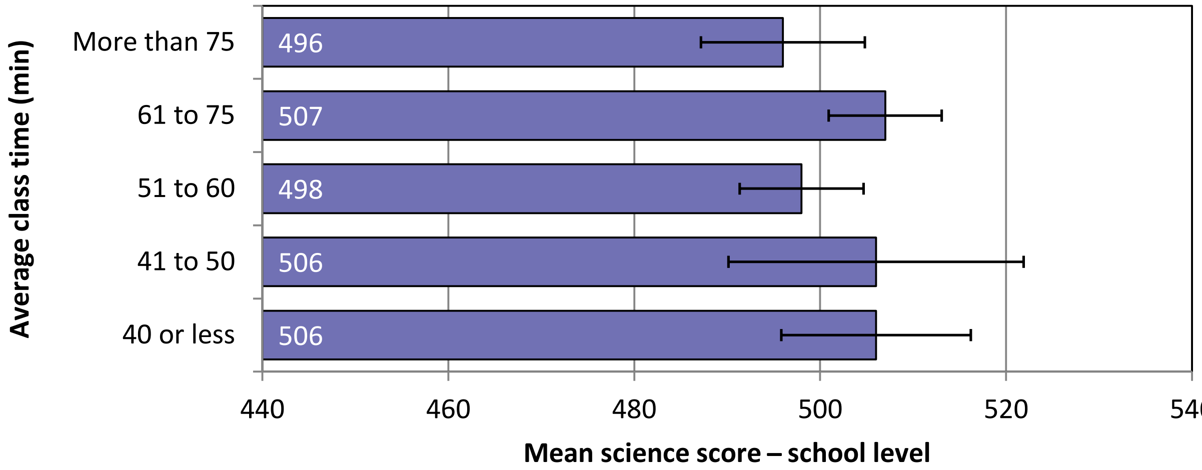


CHART 7.5 **Relationship between class time and science achievement**



Homework

While teachers are often concerned about students not completing their homework, students sometimes place a higher priority on their out-of-school activities. Meanwhile, parents have to cope with the family stress that results from monitoring homework completion (Hoover-Dempsey et al., 2001; Warton, 2001). Nevertheless, the majority of teachers, students, and parents believe that homework is a valuable and essential educational tool (e.g., Cooper et al., 1998; Xu, 2005). Despite the strong arguments put forward both for and against homework in the academic literature, it remains difficult to reach a definite conclusion about homework's value. For example, in a summary of research conducted in the United States between 1987 and 2003 on the effect of homework, Cooper, Robinson, and Patall (2006) concluded that there was generally consistent evidence for homework's positive influence on achievement but they also acknowledged that there were methodological issues with all the studies. Empirical support for a positive relationship between homework and achievement is not unequivocal (e.g., De Jong, Westerhof, & Creemers, 2000; Trautwein & Köller, 2003). However, at least for mathematics in the middle grades, spending *no time* on homework is related to lower achievement but for reading at the Grade 4 level, 15 minutes or less of homework is related to higher scores (CMEC, 2014). Two aspects of homework examined in PCAP 2013 are frequency and effort.

Teachers' homework expectations

Teachers were asked how much time they expected their students to spend on science homework each week on a scale ranging from no homework assigned to more than two hours weekly. As chart 7.6 indicates, most teachers expect their students to complete up to one hour of science homework weekly at the Grade 8/Secondary II level and a very few teachers report assigning more than two hours of weekly homework. British Columbia and Newfoundland and Labrador teachers stand out for expecting the most science homework from their students with about 30 per cent assigning one to two or more hours weekly. In contrast, more than 30 per cent of New Brunswick teachers report that they do not assign homework in science. As chart 7.7 shows, students achieve significantly higher science scores when they are assigned some homework. However, according to PCAP 2013 there is no advantage in assigning long periods of work to do at home. Results from large-scale assessments suggest that older students benefit more from homework than younger students. For Grade 4 students tested in PIRLS 2011, students who spend more than 15 minutes daily on homework achieved lower reading scores, whereas for 15-year-olds in PISA 2012, between two and three hours per day on homework was associated with the highest mathematics achievement (CMEC, 2014).

CHART 7.6 **Amount of time teachers' expect students to spend on science homework**

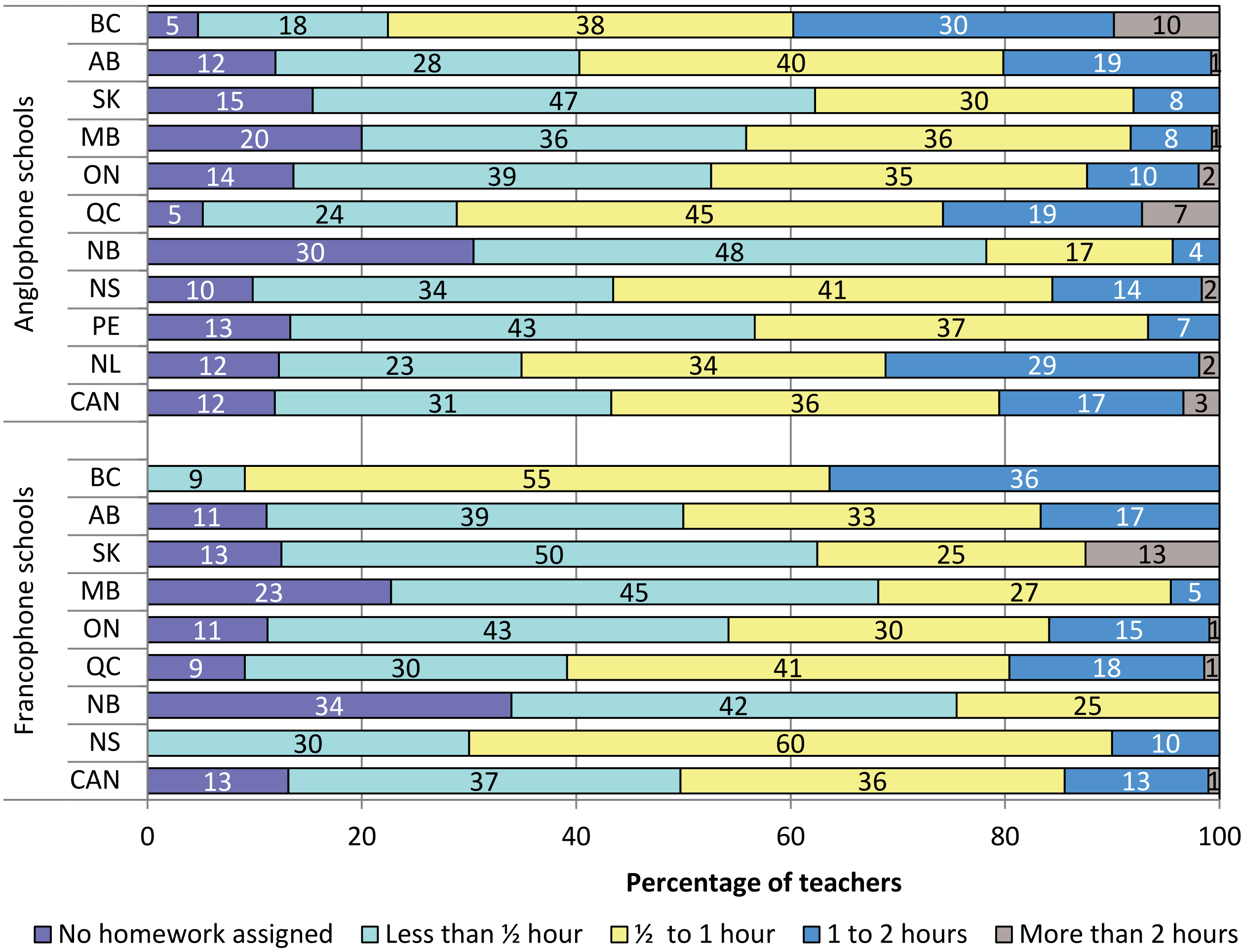
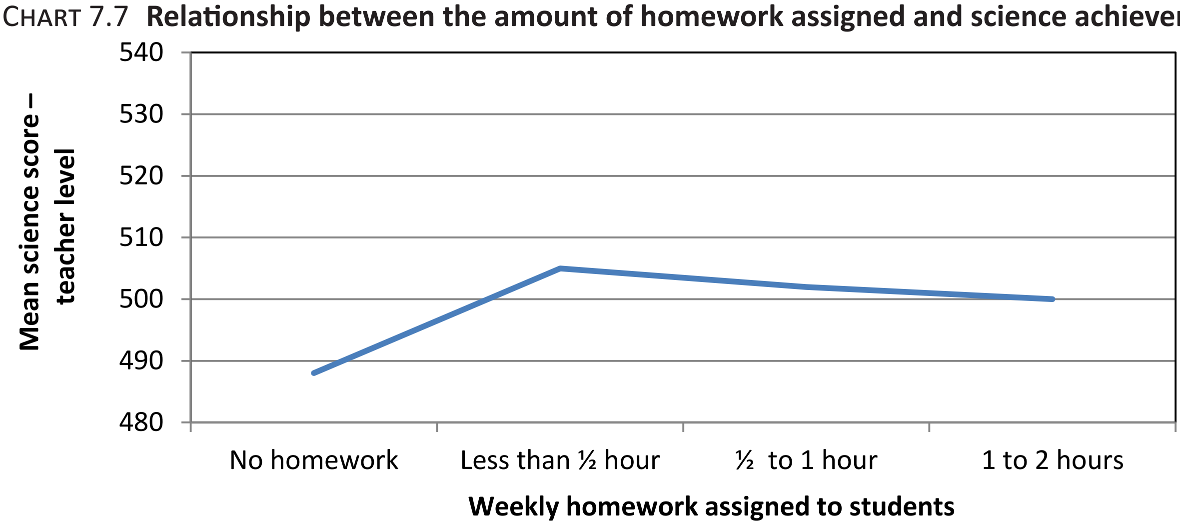
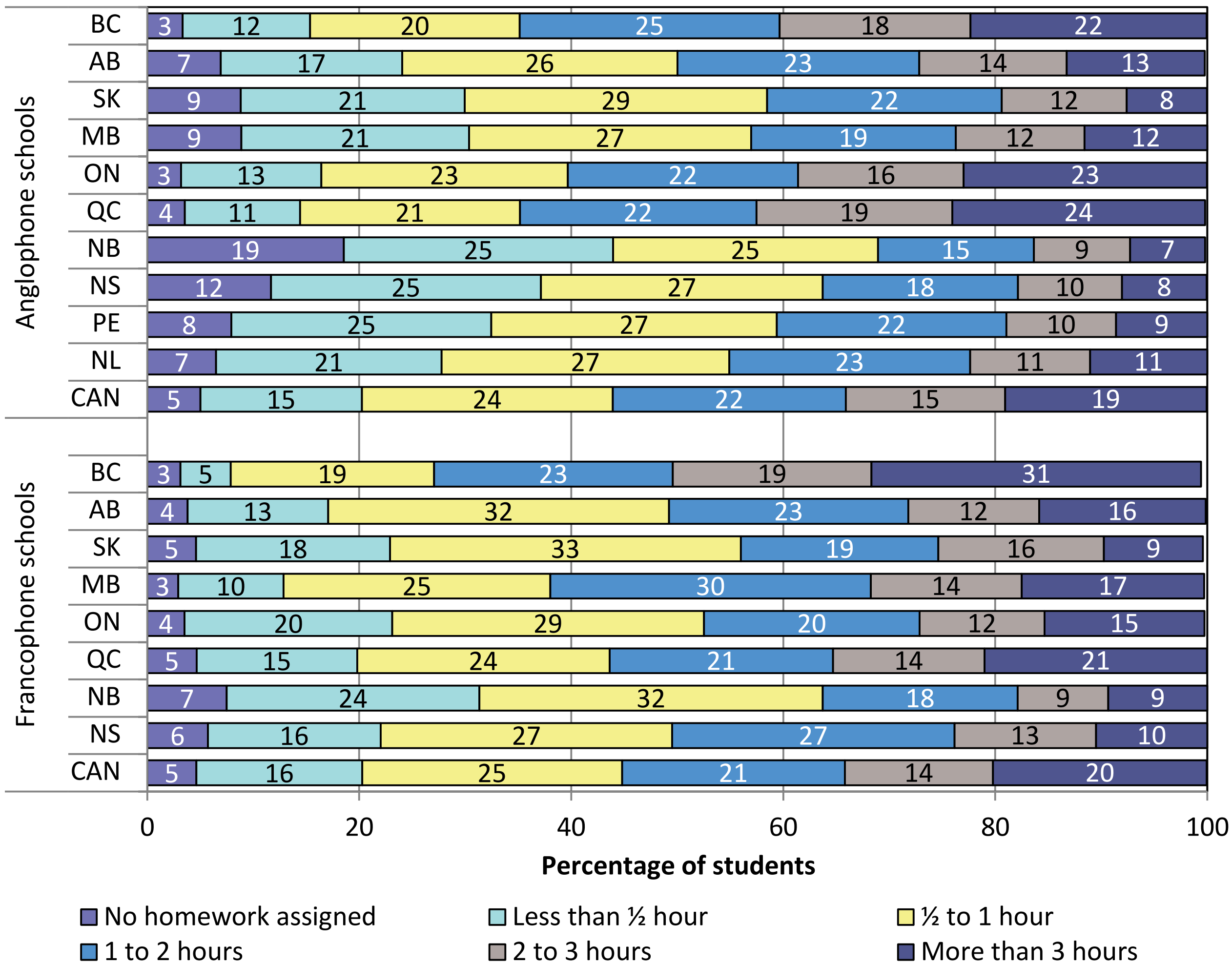


CHART 7.7 **Relationship between the amount of homework assigned and science achievement**



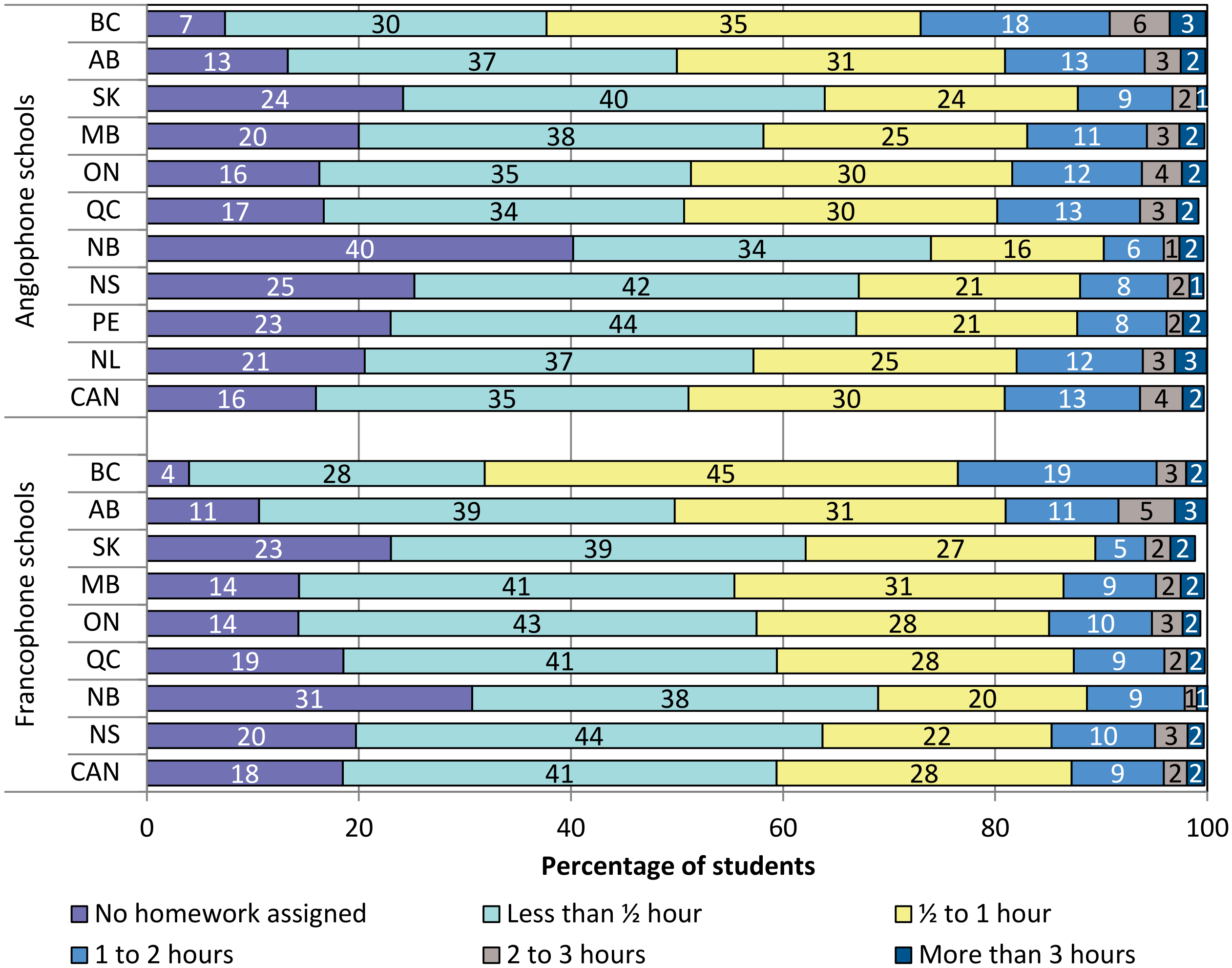
Students were asked how much they spent every week on homework in all their school subjects and specifically on science homework. As chart 7.8 presents, most students report spending between 30 minutes and two hours doing homework each week. Twenty per cent or more of students in anglophone schools in British Columbia, Ontario, and Quebec and in francophone schools in British Columbia and Quebec report spending more than three hours on homework.

CHART 7.8 **Amount of time students spend on homework in all their school subjects**



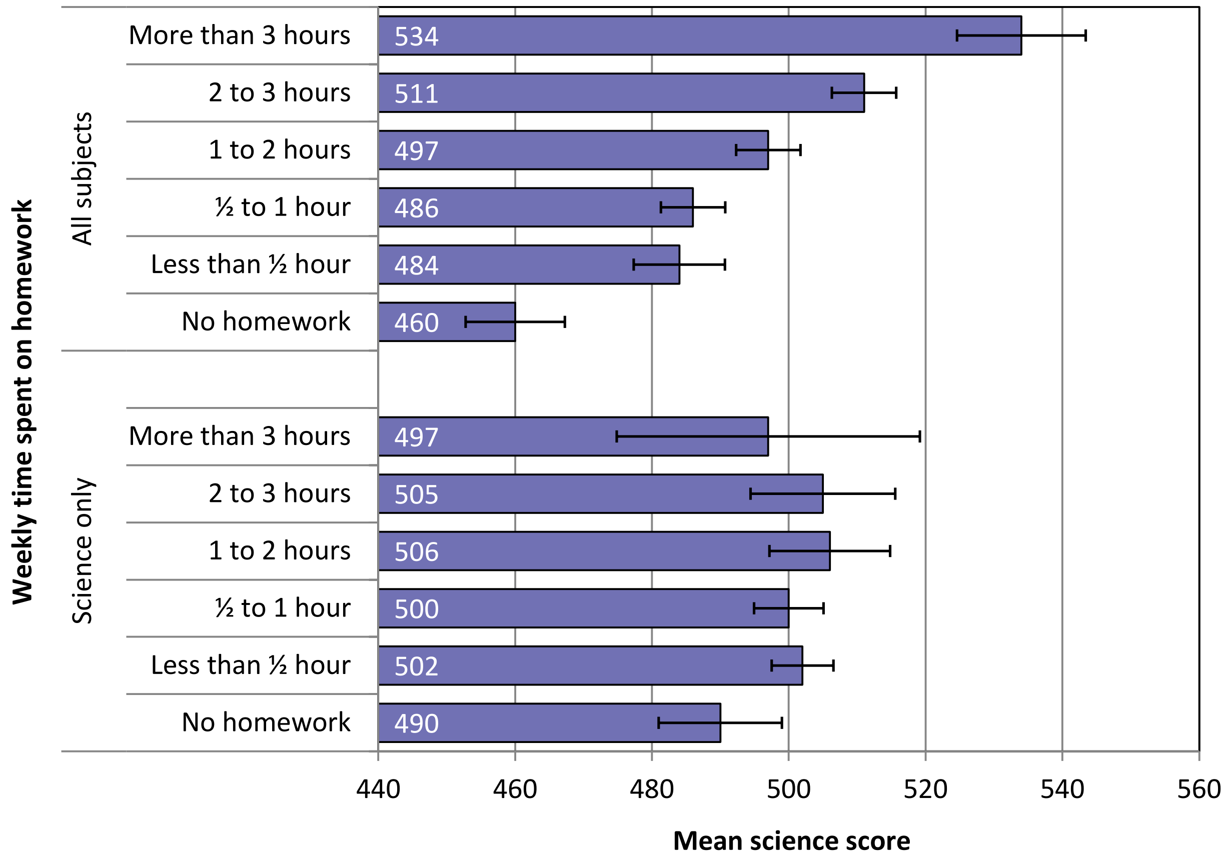
Students were also asked how much time they spend every week specifically on science homework. The time range reported most frequently is between less than 30 minutes and one hour. Students reporting more than one hour of weekly science homework are found in the highest proportion in both language systems in British Columbia and Alberta, and in anglophone schools in Quebec, whereas over 30 per cent of New Brunswick students report that no homework is assigned in science (chart 7.9).

CHART 7.9 **Amount of time students spend weekly on science homework**



The relationship between homework and science achievement is striking — students reporting the most amount of time spent on homework in all their school subjects achieve the highest scores in science (chart 7.10). Although the relationship between science homework and achievement is not linear, it is clear that doing no homework results in lower achievement. That said, the results of this study cannot point to an optimal amount of science homework that would lead to increased achievement.

CHART 7.10 **Relationship between the amount of weekly homework and science achievement**



Homework effort

The amount of time spent on homework and students' exertion on this task are different measures. Student effort is measured in this study by asking students how often they complete their homework on a four-point scale from "never" to "often." For homework in all subject areas, 6 per cent or fewer students report never completing their homework compared to between 57 and 72 per cent often completing their homework (chart 7.11). For science homework, 11 per cent or fewer report that they never complete their homework and 52 to 66 per cent report that they often complete their homework (chart 7.12).

There is a strong positive trend for higher achievement with greater homework effort as chart 7.13 presents. Students who report that they often complete their homework, whether in science or in all subjects, achieve science scores that are about 80 points higher than those who do not dedicate time to their studies at home.

CHART 7.11 **Frequency of homework completion by students in all school subjects**

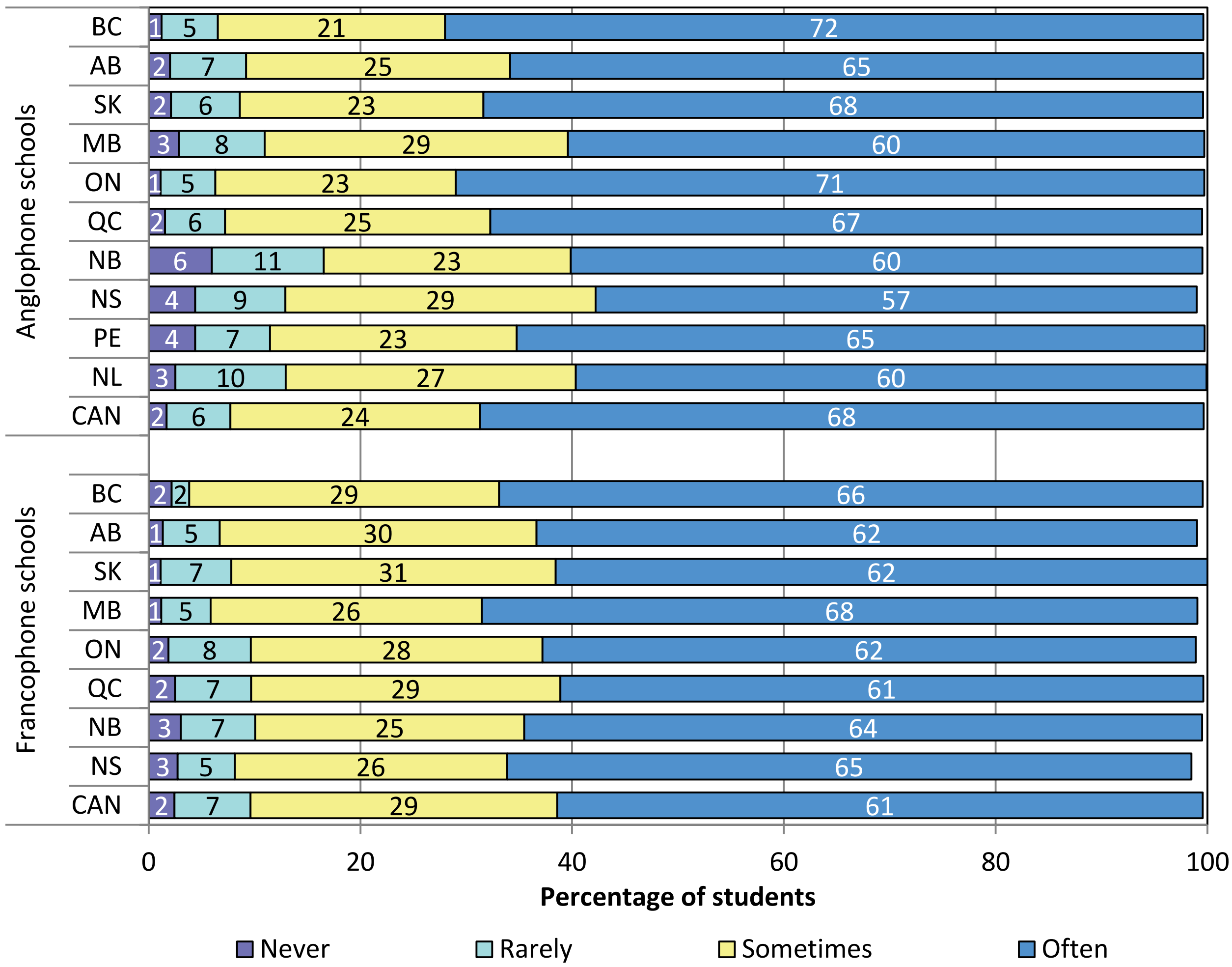


CHART 7.12 **Frequency of homework completion by students in science**

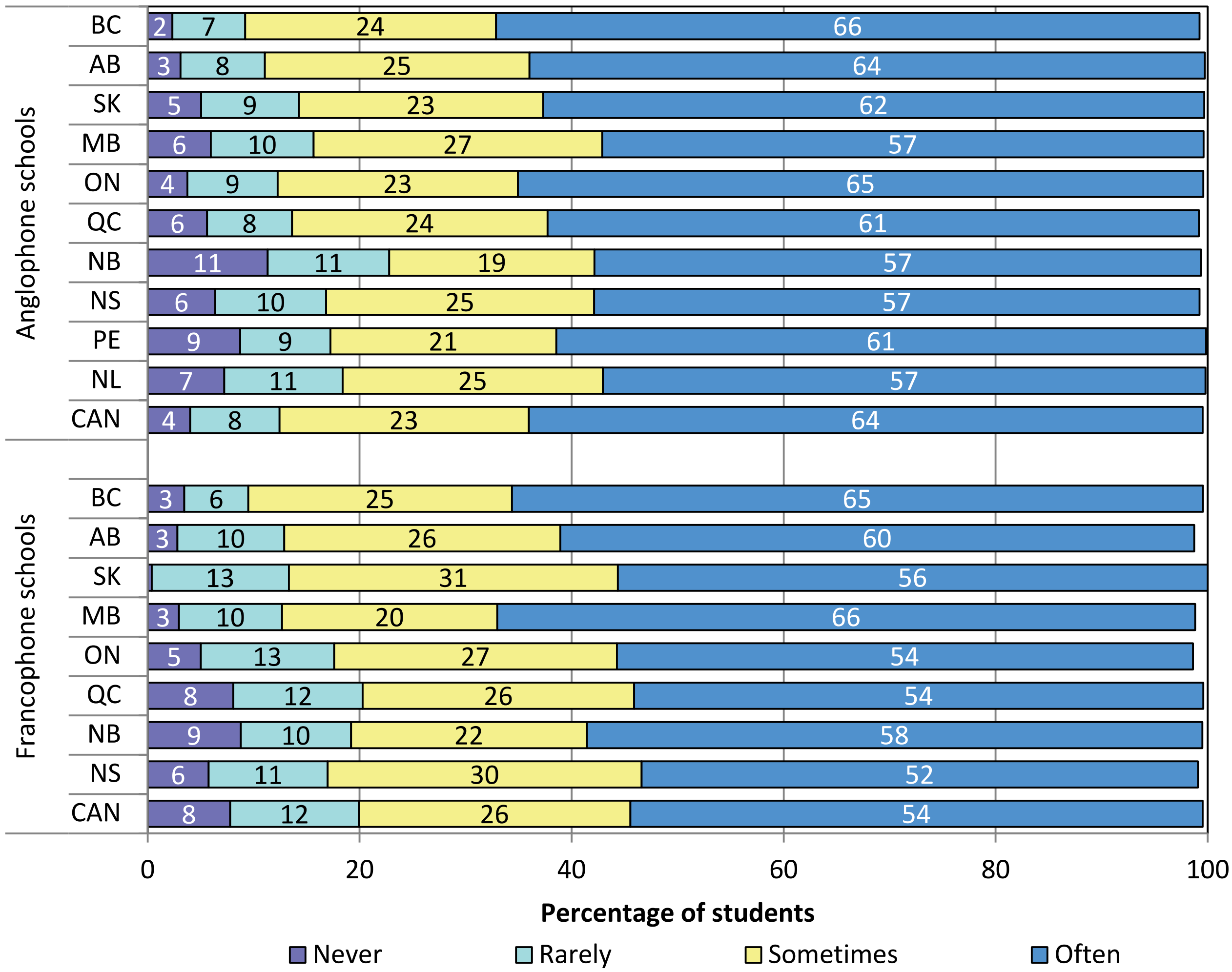
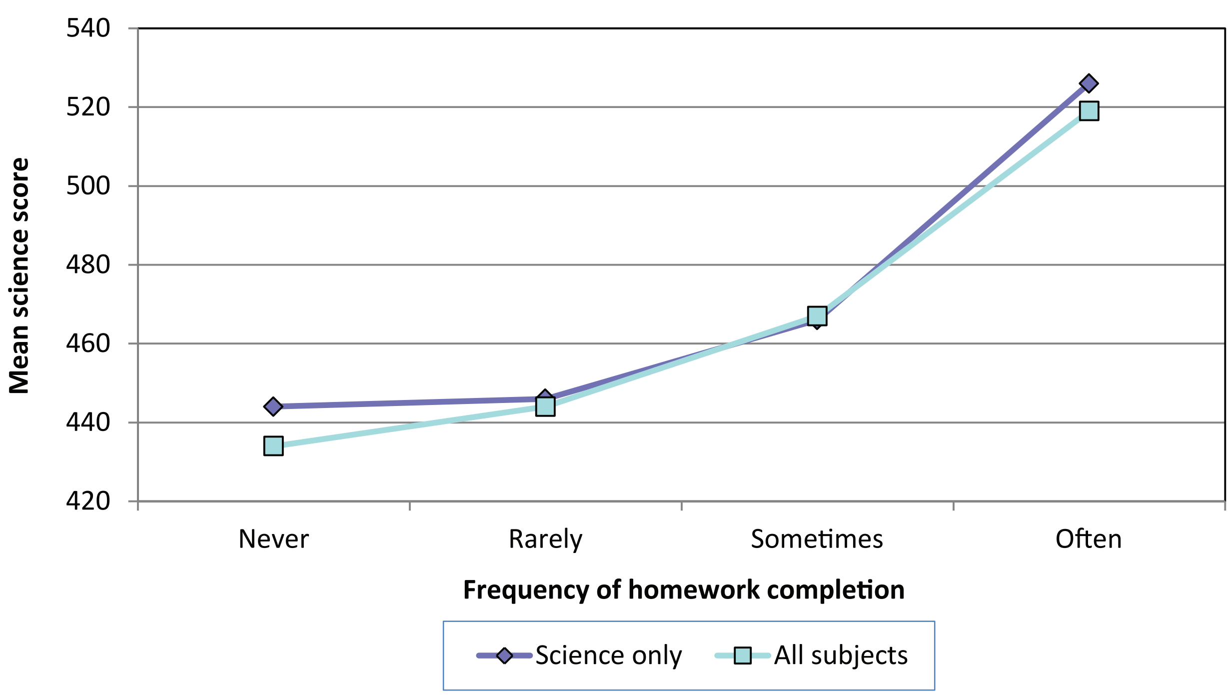


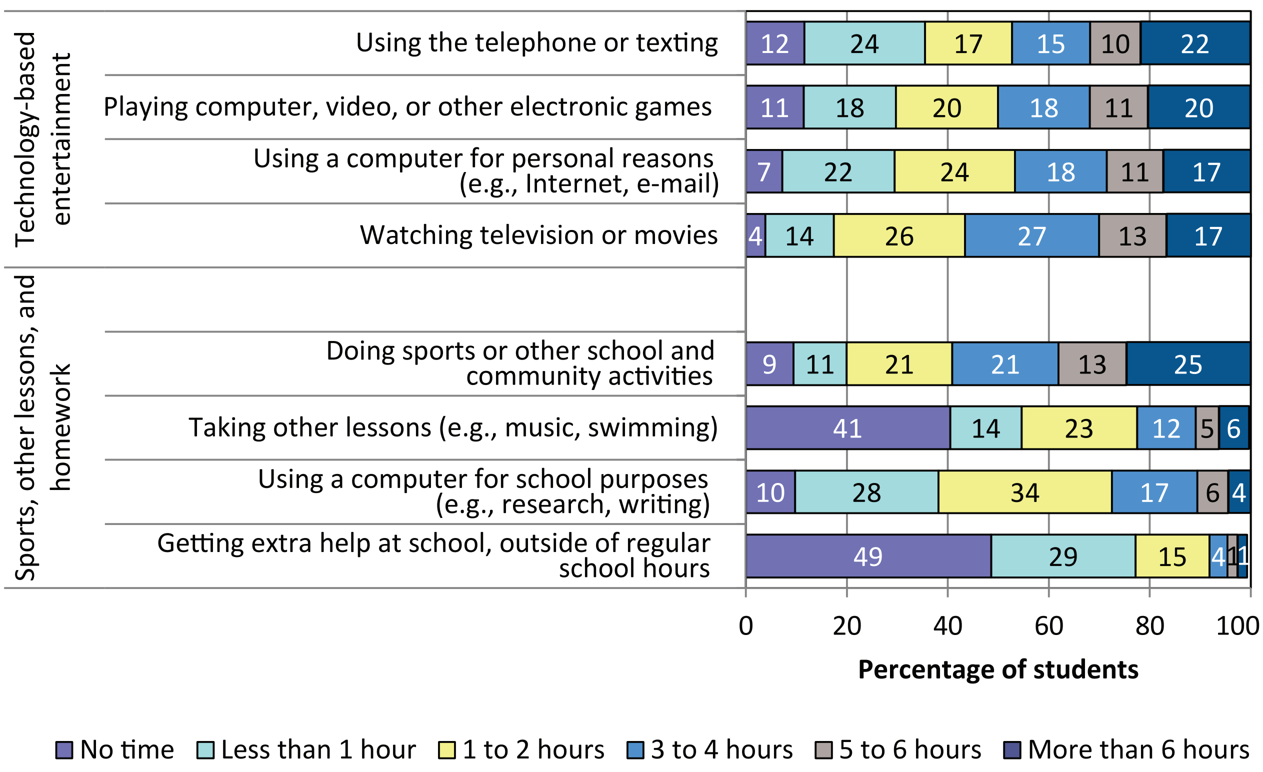
CHART 7.13 **Relationship between homework effort and science achievement**



Extended learning time

Student learning is not confined to the classroom. Learning opportunities are also provided through structured out-of-school activities such as sports or community activities as well as social interactions and technology-based entertainment. Although this study did not show a significant effect of these extended learning opportunities on achievement in science, it is interesting to discover how students in this age group use their time when they are not in the classroom. Students were asked to report on a six-point scale, from "no time" to "more than six hours," the number of hours in an average week that they usually spend doing a variety of activities. As chart 7.14 shows, students report that they spend many hours using technology for either social interaction or entertainment and almost 20 per cent of students report that they are engaged in such activities for more than six hours a week. One in four students report spending more than six hours a week on sports and other community activities and almost 60 per cent of all students report that they participate in such activities three or more hours per week. Many students are involved with other lessons, such as music or swimming lessons, and over 45 per cent of students report that they are involved with out-of-school lessons for at least an hour weekly. The activity that they engage in the least frequently involves getting extra help in their studies.

CHART 7.14 **Student use of weekly out-of-school time**



Loss of learning time

One of the earliest conceptual models of school learning postulated that the degree of school learning is a function of both the amount of time actually spent in learning and the time needed to learn Carroll (1963). Schools schedule the amount of learning time on a yearly, weekly, and daily basis. The time needed to learn, however, is dependent on characteristics of the learners themselves and their interaction with the knowledge or skills on which their learning time is focused. The efficiency of this process is undermined when learning time is lost or disrupted.

Loss of instructional days

Teachers were asked how many instructional days in a school year are lost for a variety of instructional and non-instructional reasons as table 7.1 shows. Only three of the types of activities listed are found to have a significant relationship with science achievement: test/exams outside of class sessions, field trips and excursions, and closings due to weather. The impact of lost days for activities related to tests/ exams or field trips does not have a linear relationship with achievement although there tends to be higher achievement with fewer days lost for weather and assessments as represented in chart 7.16. The loss of time resulting from the weather occurs to some extent in all jurisdictions across Canada. However, teachers in Newfoundland and Labrador report the greatest frequency as do francophone teachers in Ontario, with weather accounting for the loss of at least 10 days of school in the school year in which PCAP 2013 was administered (chart 7.16). Not surprisingly, Atlantic Canada stands out for enduring the highest frequency of weather-related time loss whereas schools in British Columbia are the least affected by weather.

TABLE 7.1 **Questionnaire items for loss of class time for non-instructional reasons**

On average, how many FULL instructional days in a *school year* are used for the following?
Tests/exams taken outside of regular class sessions (*include marking days*)
Field trips or excursions (music, cultural, etc.)
Sports activities
School-spirit days
Closings due to weather
Other non-instructional activities

CHART 7.15 **Relationship between the loss of class time for non-instructional activities and science achievement**

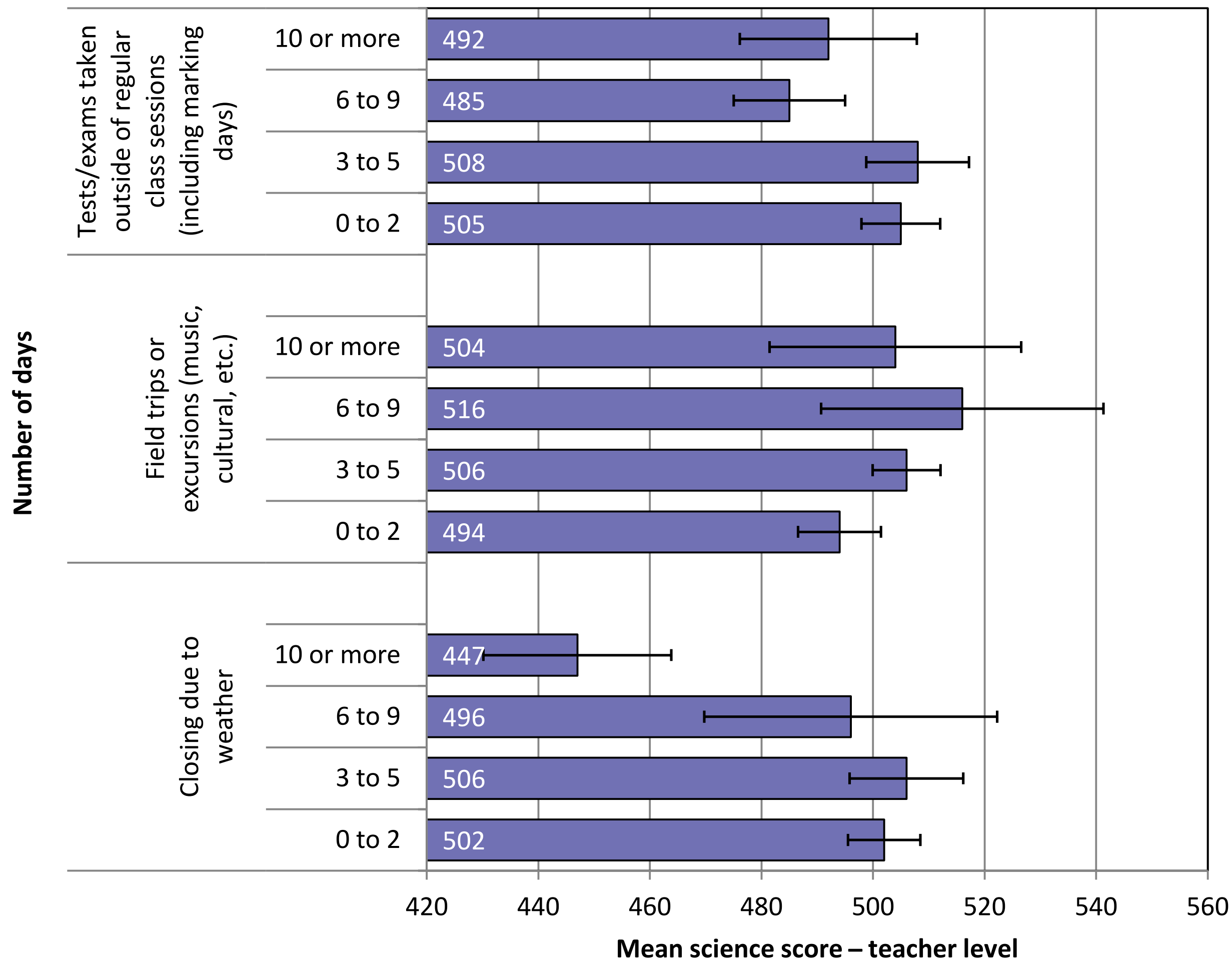
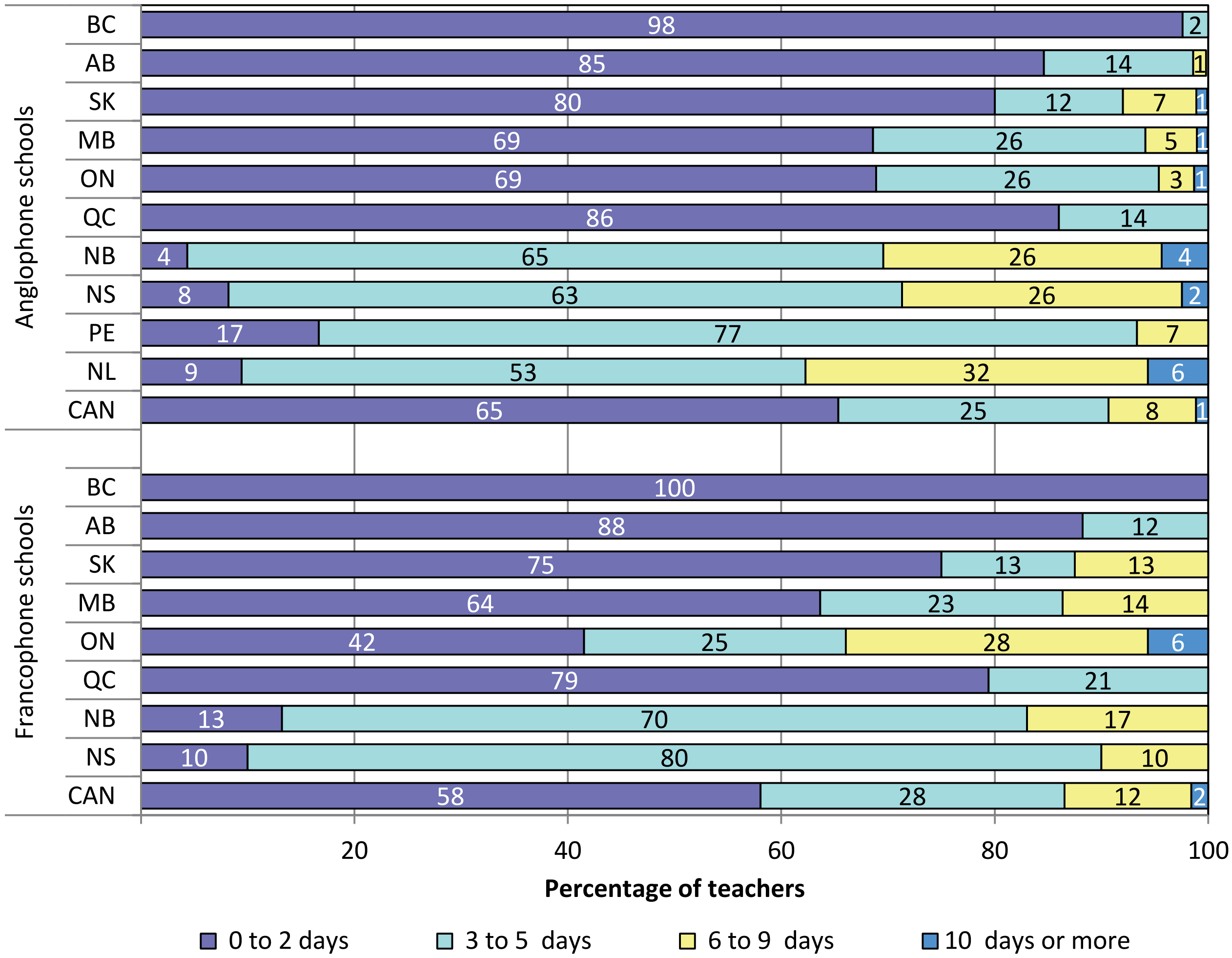


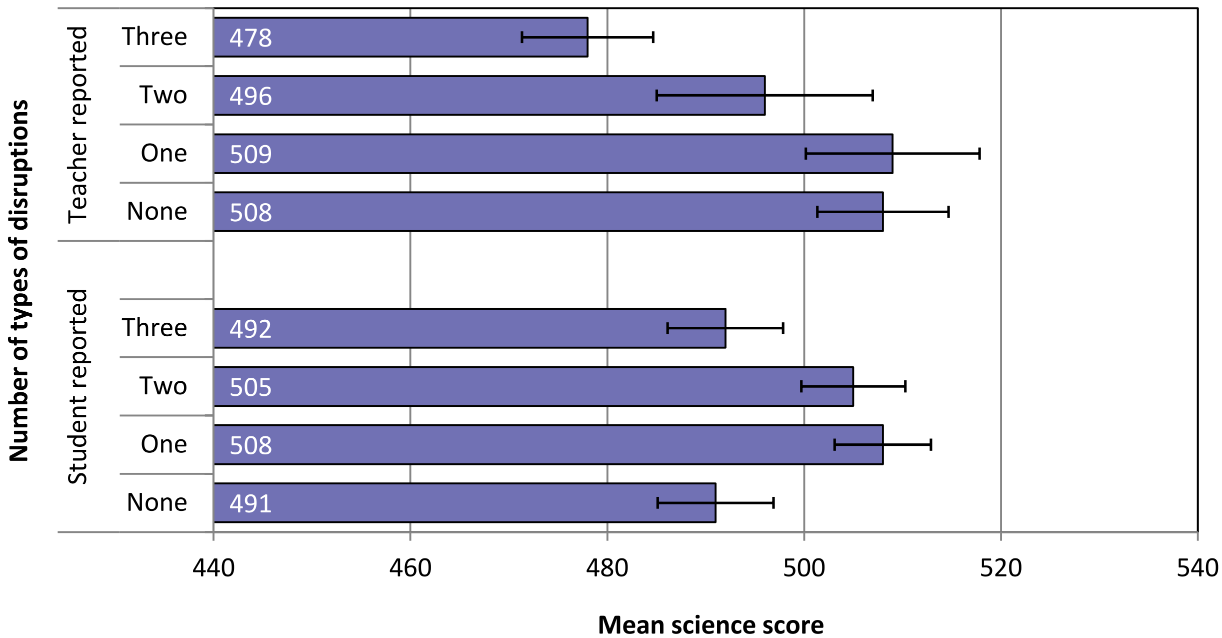
CHART 7.16 **Teacher-reported loss of instructional days due to weather**



Time lost by disruptions

Both teachers and students were asked how often time was lost because of student misbehaviour, other disruptions (e.g., announcements, assemblies, visits), and discussions unrelated to the science lesson. Individually, the types of disruptions did not yield a significant relationship with achievement. However, classrooms with more than one type of disruption tended to have lower achievement and this was perceived to be a greater problem from the teachers' perspective than the students' (chart 7.17).

CHART 7.17 **Relationship between the frequency of classroom disruptions and science achievement**

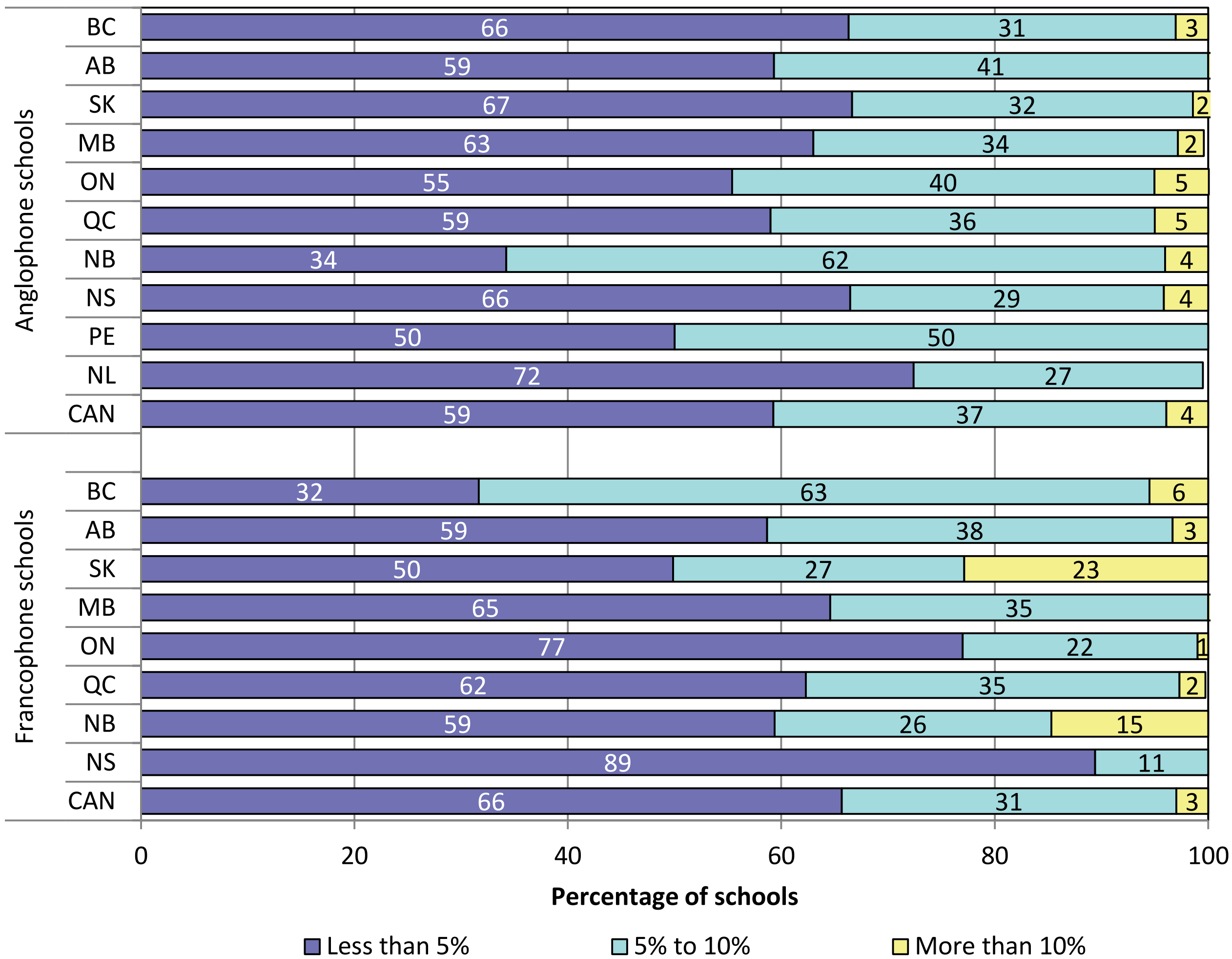


Student absence

It goes without saying that learning opportunities are lost when students are not in their classes. Data on student absence are available from both the school and student questionnaires.

The rate of student absence reported by school principals appears in chart 7.18. The lowest absence rates are reported by schools in Newfoundland and Labrador and francophone schools in Ontario and Nova Scotia. The highest rate of absenteeism is reported by principals in francophone schools in Saskatchewan and New Brunswick where 15 per cent or more students are absent on a weekly basis for reasons unrelated to school. Because the school absence rate's relationship to the mean science score is not a linear relationship a more in-depth study is required to gain a clearer understanding of this relationship.

CHART 7.18 **Percentage of students absent on a typical day for reasons other than school-sponsored activities**



Students were asked to report the number of school days that they missed this year. This information appears in table 7.2. For school-related activities, fewer than 10 per cent of students report missing 10 or more days of school in all anglophone schools and most francophone schools. Three francophone populations report a higher frequency of absenteeism for school-related reasons: Saskatchewan (29 per cent), Manitoba and Ontario (13 per cent). The percentage of days missed for reasons unrelated to school is much higher for all populations than that reported for school-related absences. In the anglophone school system, the percentage of students missing 10 or more days ranged from 23 per cent in Quebec to 45 per cent in Newfoundland and Labrador. In francophone schools, the percentage of students missing 10 or more days ranged from 19 per cent in Quebec to 32 per cent in Nova Scotia.

As with any survey, student self-reports demand cautious interpretation and it is important to further explore student- and school-level data to identify the underlying reasons for absenteeism in schools and their impact on learning.

Table 7.2 **Student-reported absence rate**

	Absent for school-related activities						Absent for reasons unrelated to school					
	0 to 2	**3 to 5**	**6 to 9**	**10 to 14**	**15 to 20**	**more than 20**	**0 to 2**	**3 to 5**	**6 to 9**	**10 to 14**	**15 to 20**	**more than 20**
Anglophone schools												
BC	64	22	9	3	1	1	31	24	20	11	6	8
AB	48	32	12	5	1	1	20	22	19	17	10	11
SK	46	32	14	5	2	2	16	23	24	17	10	11
MB	46	32	13	5	1	2	25	25	21	13	8	8
ON	45	33	14	5	2	1	21	26	22	14	9	8
QC	57	25	11	3	1	1	26	31	20	13	5	4
NB	56	27	10	3	1	1	24	24	22	14	8	9
NS	54	30	11	4	1	1	16	23	22	19	10	11
PE	49	34	10	4	1	1	14	23	23	17	13	9
NL	58	28	9	3	1	1	12	23	20	18	15	12
CAN	**50**	**30**	**12**	**5**	**1**	**1**	**22**	**25**	**21**	**14**	**9**	**9**
Francophone schools												
BC	48	28	16	4	3		24	24	23	13	9	5
AB	48	24	16	6	3	2	26	25	17	15	8	9
SK	27	22	22	10	12	7	24	28	20	12	7	8
MB	26	41	20	8	4	1	27	26	24	11	7	4
ON	34	32	19	8	3	2	21	26	22	15	8	7
QC	59	27	10	3	1	1	36	28	17	9	5	5
NB	62	26	7	2	0.3	1	27	30	21	11	6	5
NS	44	32	16	3	1	2	19	25	22	17	9	6
CAN	**57**	**27**	**11**	**3**	**1**	**1**	**35**	**28**	**18**	**9**	**5**	**5**

Summary

This chapter explored issues surrounding time management in schools, including scheduling learning time, homework and out-of-class activities, time lost for absenteeism, and disruptions.

Doing homework has a positive relationship with achievement. Students who spend more time on homework each week for all subjects and who report higher homework effort attain higher scores not only in science but in all school subjects.

When not in school, one in four students are involved with sports or other activities related to their schools or communities for more than six hours weekly and 80 per cent of students participate in such activities for an hour or more each week. Almost 60 per cent of students pursue sport or cultural interests through other lessons each week. Although many parents worry about the extensive time that adolescents spend on technology-based entertainment and its impact on their social and cognitive skills, only about 20 per cent of students spend more than six hours weekly engaged in such pursuits and about 10 per cent do not spend time in this way. This may be an interesting insight into the extended learning time of students.

8 ASSESSMENT

Teachers use assessment to gain insight into students' current ideas, gaps in understanding, and reasoning processes. This information can then be used to adapt instructional and assessment strategies to student needs. The power of assessment to reveal and support learning depends on how well students' responses authentically reflect their thinking and understanding (Shepard, 2005). Questions about assessment are included in each of the three PCAP questionnaires. Questions for teachers have two main focal points. The first looks at assessment practices, including strategies and questioning methods. The second examines the use of external exams and non-academic criteria for assigning grades. Students were asked about the use of rubrics and feedback in their classes and school principals were asked about curriculum accountability.

Methods of classroom assessment

Assessment types

Teachers were asked a variety of questions about their classroom assessment practices. Their responses were used to develop a picture of the assessment types (table 8.1), question styles (table 8.2), and different levels of students' thinking (table 8.3) that teachers use to determine the progress of learning in their classrooms. Surprisingly, no clear pattern emerged about the relationship between the various ways that students are assessed and their achievement in science. Indeed, a very small proportion of teachers surveyed (approximately 1 per cent) reported that they did not use any of the assessment methods listed in table 8.1 which may indicate that Canadian science teachers use a more extensive range of assessment practices than this survey represented. Nevertheless, this information can provide an informative picture of the variety of ways that teachers attempt to determine what their students understand and what they can do in science.

Teachers were asked how often they assess in each of the seven methods listed in table 8.1, using a four-point scale (never, rarely, sometimes, or often). The proportion of teachers reporting that they use these methods sometimes or often appears in the table in decreasing order of frequency for Canada overall. Teacher-developed tests and individual student assignments are the most common assessment method that teachers use. Unsurprisingly, teacher-developed tests are used more frequently than common school-wide tests (97 per cent vs. 26 per cent). Although collaboration is encouraged in many school districts, this may be directed more toward sharing strategies and the development of resources to be used by teachers in their classrooms rather than the development of shared assessment instruments. Collaboration on the development of school-wide tests may be limited to those administered at the end of a course, in part because of the time needed for teachers to come together for such a development project. Summative assessment at the end of units and ongoing formative assessment of students would remain under the purview of individual teachers. The only method surveyed that is significantly related to achievement is performance assessment. Examples of performance assessment tasks include designing a research project, an investigation, or a machine. Teachers who assess their students most frequently based on their performance are teaching in anglophone schools in Ontario and francophone schools in Alberta and Saskatchewan (chart 8.1).[33] Students in classrooms where their teachers report using performance assessment "sometimes" or "often" achieve higher scores in science than those in classrooms who are "never" or "rarely" assessed in this way (chart 8.2). This type of assessment is used both during classroom assessment (72 per cent, table 8.1) and as part of teacher-developed tests (65 per cent, table 8.2). This suggests that teachers are giving their students the opportunity to show their understanding of science in multiple ways. Whereas more traditional assessment determines what students know about science, performance assessment allows students to show what they know about doing science, which would be an authentic representation of knowledge in this domain.

The assessment of a student's performance can be thought of as a scaffold to support learning. Educational researchers propose that strategic combinations of scaffolds can prompt students across all achievement levels to more readily use what they know; however, the scaffolding must be of high quality. Kang, Thompson, and Windschitl (2014) suggest that for science teachers who are interested in designing assessment tasks to support and enhance student learning, a combination of multiple types of scaffolding, including the use of contextualized phenomena, is necessary. Thus performance assessment used in authentic ways may further promote student understanding in science. Teachers were asked about their use of performance assessment in two ways: more broadly as part of their assessment in class and specifically as a component of teacher-designed tests.

Table 8.1 **Types of classroom assessment and frequency of teachers' use**

In the science class selected for PCAP 2013, how often are students assessed in the following ways?	Sometimes or often (%)
Teacher-developed classroom tests	97
Individual student assignments/projects	94
Group assignments/projects	86
Performance assessment	72
Homework	44
Student portfolios and/or journals	40
Common school-wide tests or assessments	26

[33] Totals may not sum to exactly 100 per cent because of rounding.

CHART 8.1 **Teachers' use of performance assessment in science**

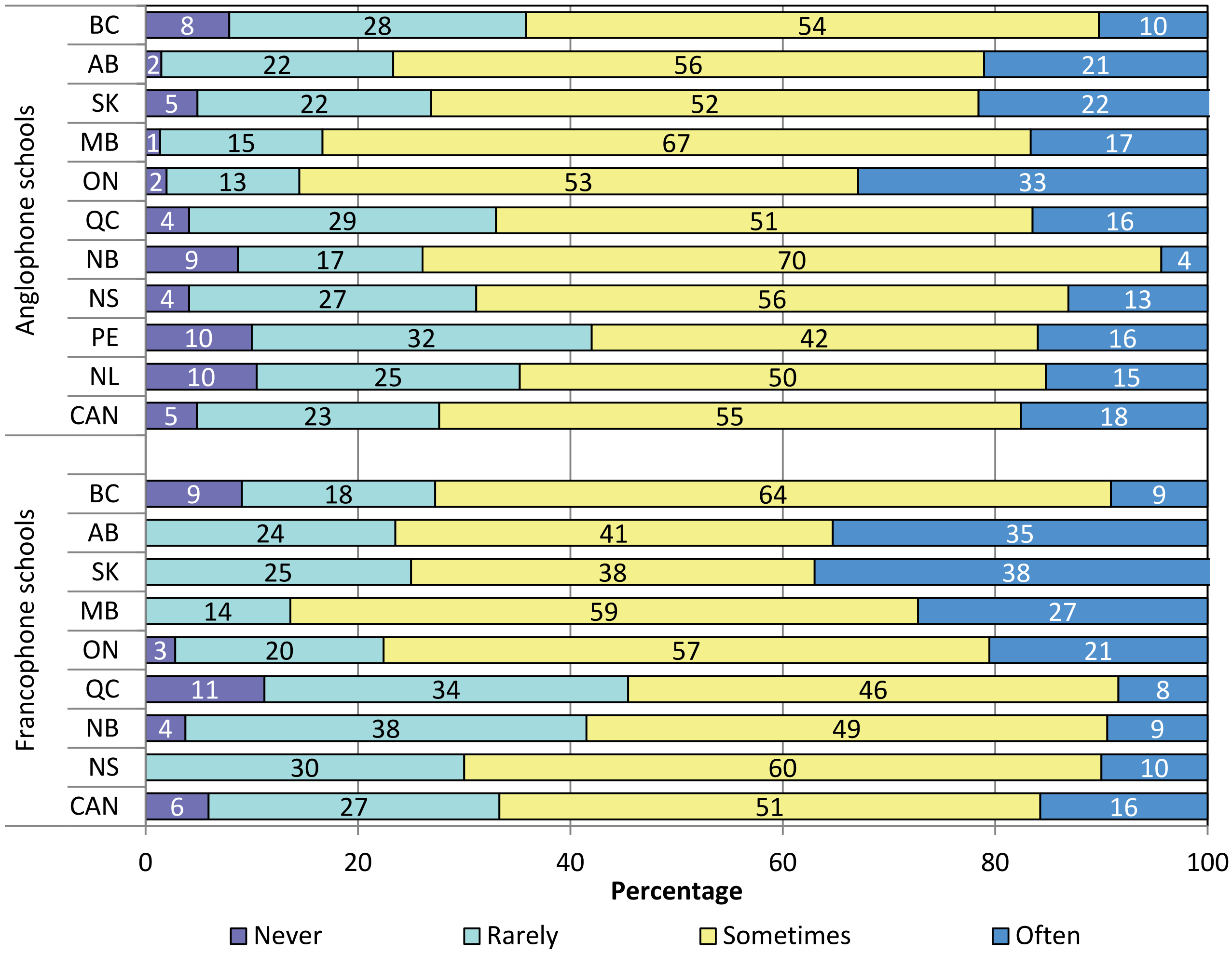
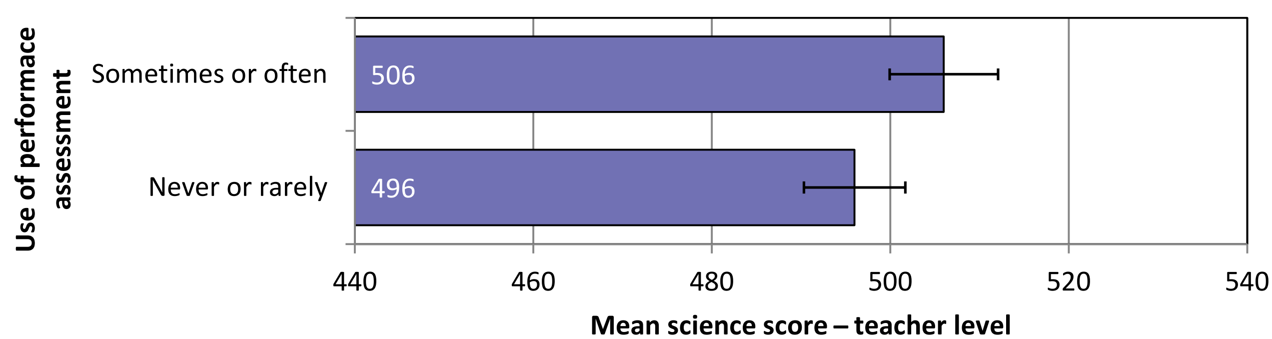


CHART 8.2 **Relationship between the use of performance assessment and science achievement**



Question types

There is much debate on the use of multiple-choice versus constructed-response tests in which students must communicate their knowledge and understanding using methods such as text, graphs, or tables. Much of the debate has focused on equivalency related to difficulty, reliability, validity, and psychometrics. There are numerous research articles in favour of each type of test in addition to mixed-methods tests that use a combination of both response types. It appears that a broad range of assessment tools is needed to capture important learning goals and processes and to more directly connect assessment to ongoing instruction (Shepard, 2000).

As table 8.2 shows, overall in Canada, Grade 8/Secondary II teachers report that they use constructed-response questions most frequently to assess their students' understanding. Selected-response items are used sometimes or often by 84 per cent of the teachers surveyed, whereas the assessment of performance in science is used less frequently (65 per cent). While performance or authentic assessment moves students closer to being able to use what they know, it also takes more time to assess and requires greater judgment (Gronlund & Waugh, 2009).

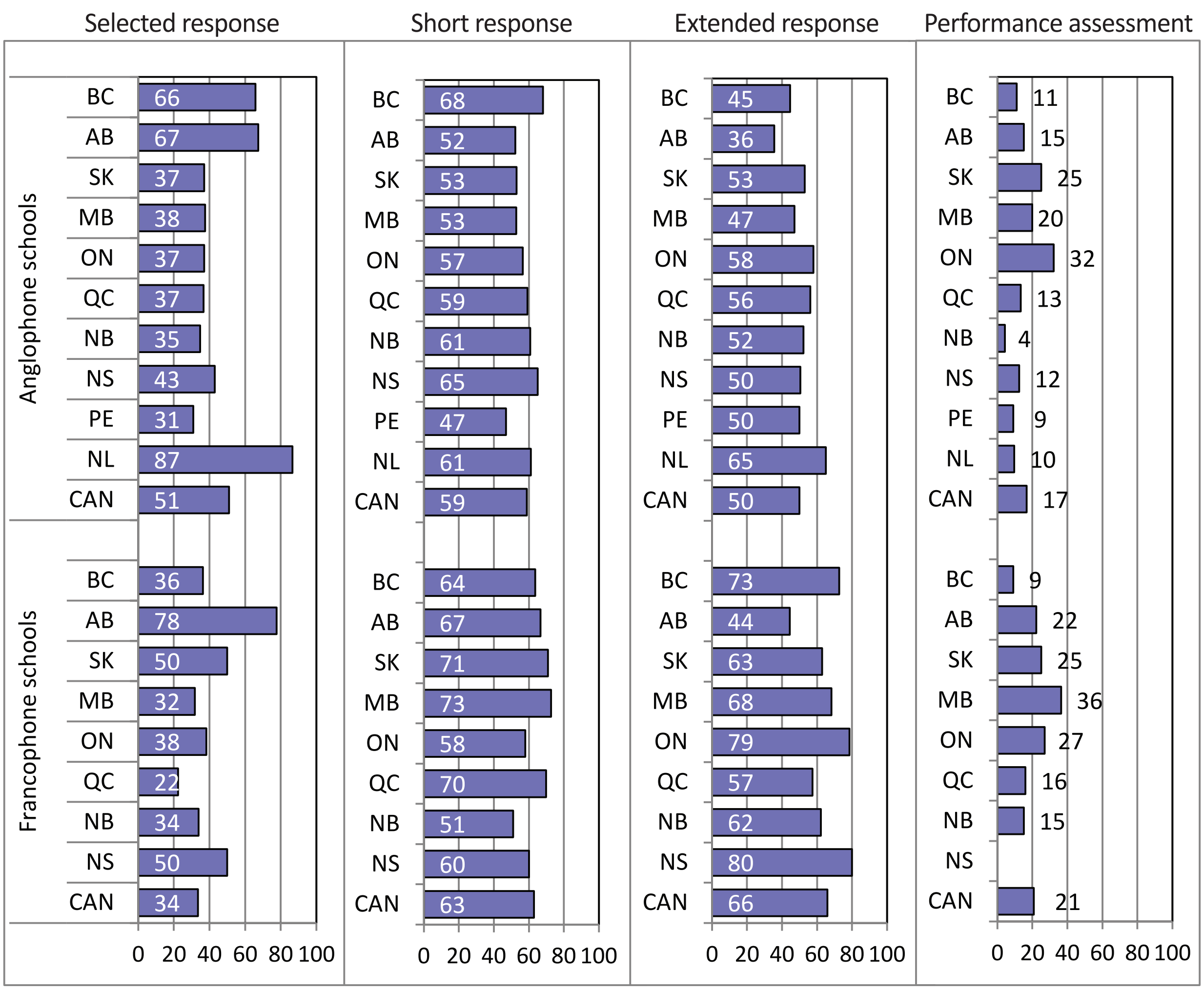
Table 8.2 **Types of questions teachers use on science tests and frequency of their use**

In your teacher-developed science tests/examinations, how often do you use the following kinds of items or questions?	Sometimes or often (%)
Short-response items (e.g., one or two words, facts, short sentences)	96
Extended-response items requiring an explanation or justification	92
Selected-response items (e.g., true/false, multiple choice)	84
Performance assessment	65

Responses by population for the use of different types of items are quite variable, as chart 8.3 indicates. Some general patterns indicate that:

- Anglophone teachers in British Columbia, Alberta, and Newfoundland and Labrador and francophone teachers in Alberta report using selected-response item types with the highest frequency.
- Overall, both short-and extended-response questions are used more frequently in most populations compared to selected-response and performance assessment. Francophone teachers report using both short- and extended-response items more frequently than anglophone teachers.
- Approximately one in three teachers often use performance assessment as part of their tests in anglophone schools in Ontario and francophone schools in Manitoba.

CHART 8.3 **Percentage of teachers "often" using specific item types on tests**



Probing levels of thinking

Teachers use a variety of different types of questions to probe students' level of thinking when they interact with science concepts. Although the use of individual techniques is not shown to be significantly related to achievement in science, teachers report that they often seek evidence of their students' procedural as well as conceptual knowledge. In Canada overall, more than 60 per cent of teachers often ask their students to know facts and concepts and apply their knowledge while about one-half of teachers report that they often expect their students to show their understanding in creative ways or by doing assessment items that would be considered authentic. Only about one-third of teachers often ask students to explain or evaluate information (table 8.3).

TABLE 8.3 **Questionnaire items related to how often questions to measure different levels of thinking are used in classroom assessment**

In your classroom assessment, how often do you include questions to measure the following levels of thinking?	Often (%)
Knowledge of facts and concepts (e.g., recall, identify, label)	64
Ability to apply knowledge and understanding (e.g., solve a problem, apply information to a new context)	62
Ability to develop hypotheses and design scientific investigations (e.g., create, design, perform)	53
Ability to explain, justify, evaluate	30

Responses by population are given in table 8.4. There is a lot of variability both within and between jurisdictions. Overall, francophone teachers more frequently report that they often expect their students to have factual knowledge, be creative and develop or design their investigations, and explain or evaluate their work. The same proportion of anglophone and francophone teachers report that they use application-based questions in their assessments.

TABLE 8.4 **Percentage of teachers "often" measuring specific levels of thinking**

	Factual knowledge	Application of knowledge	Create, design, perform	Explain, justify, evaluate
Anglophone schools				
BC	71	65	46	19
AB	63	71	49	27
SK	53	54	47	28
MB	67	48	45	29
ON	54	65	70	38
QC	56	62	60	38
NB	57	57	30	22
NS	55	61	48	27
PE	50	44	28	16
NL	73	72	56	26
CAN	**62**	**62**	**50**	**27**
Francophone schools				
BC	73	64	64	27
AB	72	89	67	39
SK	75	63	75	50
MB	50	55	64	32
ON	79	71	79	49
QC	75	60	51	38
NB	46	51	51	30
NS	70	40	40	0
CAN	**70**	**62**	**61**	**40**

Rubrics and feedback

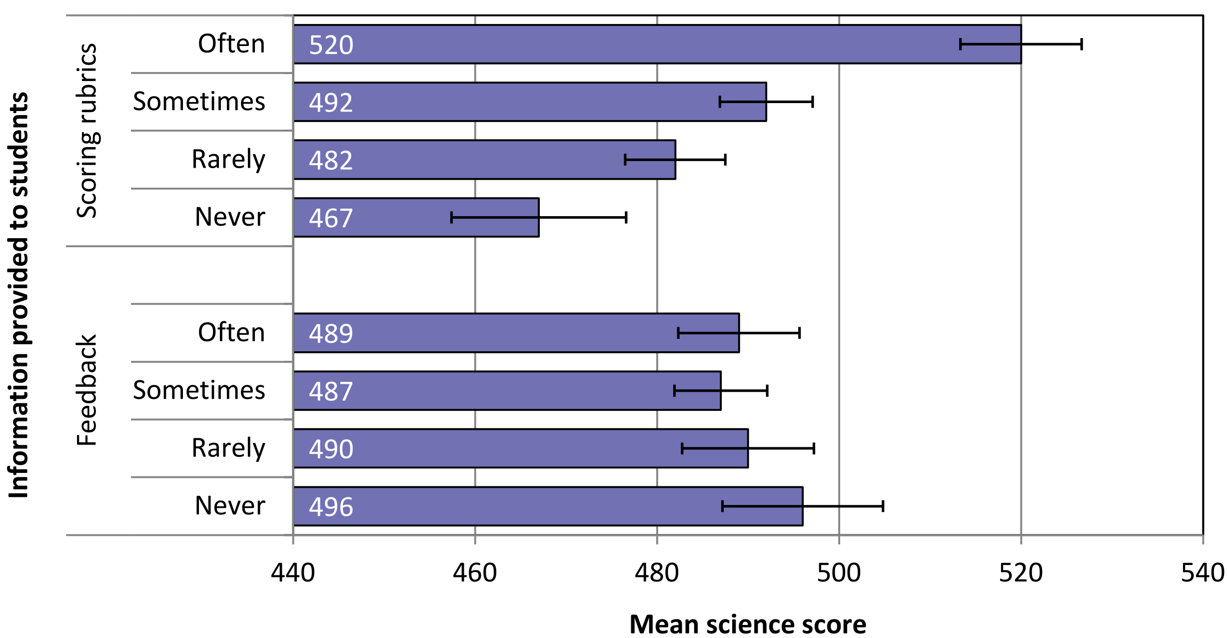
Assessment is integral to learning (Gronlund & Waugh, 2009) so it requires a systematic, planned process to collect data that can result in improvements in both teaching and learning. To make the assessment of learning more transparent for students, teachers are increasingly providing them with information both before and after their work to communicate goals and expectations.

Rubrics provide a shared understanding of the specific, pre-established criteria that will be used to evaluate their work. Huba and Freed (2000) elaborate how "a rubric reveals, if you will, the scoring 'rules.' It explains to students the criteria against which their work will be judged. More importantly for our purposes, it makes public key criteria that students can use in developing, revising, and judging their own work" (p. 155).

Whereas a scoring rubric provides students with assessment-related information prior to being evaluated, feedback provides students with information afterwards to help them improve their learning. Researchers have suggested that providing feedback might foster improved learning, motivation, and achievement. However, to be effective, feedback has to be timely and focused on understanding and improvement, comparative performance, or both (Muis, et al., 2013).

Students were asked how often their teacher provides details about how tests or assignments will be scored (e.g., scoring rubric) and how often feedback is provided to help improve their learning. Both of these variables were used in a model to predict achievement and appear in chart 8.4. The use of scoring rubrics has a stronger relationship with achievement than the use of feedback when the two are considered together. There is a general pattern of higher science scores with increased use of scoring rubrics.

CHART 8.4 **Relationship between the use of scoring rubrics and feedback and science achievement**



In Canada overall, 81 per cent of students report that they are sometimes or often provided with marking details for their tests and assignments in advance, and 78 per cent of students report that their teachers sometimes or often provide feedback. As chart 8.5 shows, the proportion of students who report that their teachers often provide them with marking details in advance (e.g., rubrics) is 45 per cent or more in anglophone schools in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Nova Scotia and in francophone schools in Saskatchewan, and Manitoba.

Chart 8.6 shows that the proportion of students who report that their teachers often provide them with feedback is 40 per cent or more in anglophone schools in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Nova Scotia, and Newfoundland and Labrador and in francophone schools in British Columbia, Saskatchewan, and Manitoba.

CHART 8.5 **Student reports of teachers' frequency providing marking details in advance**

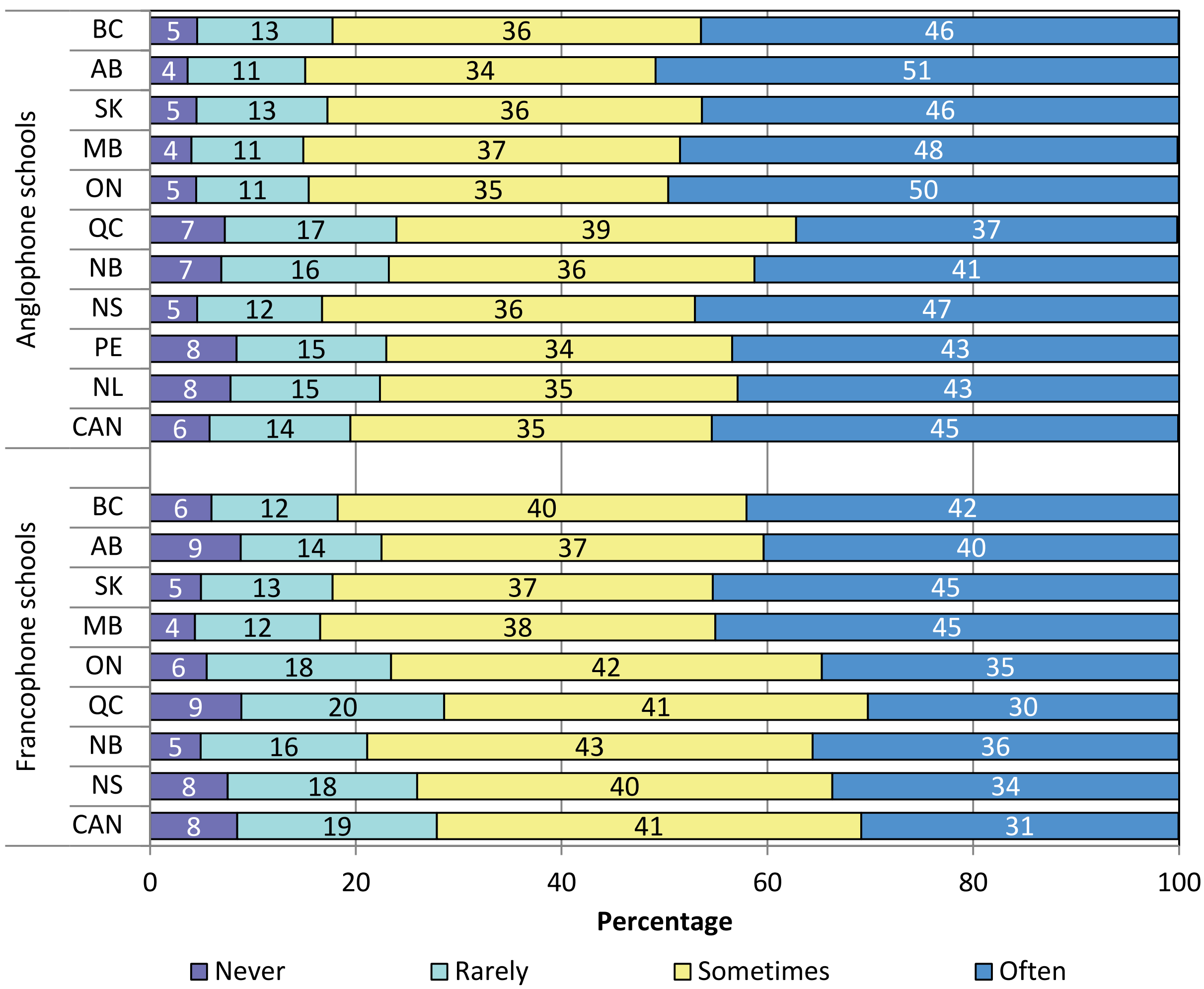
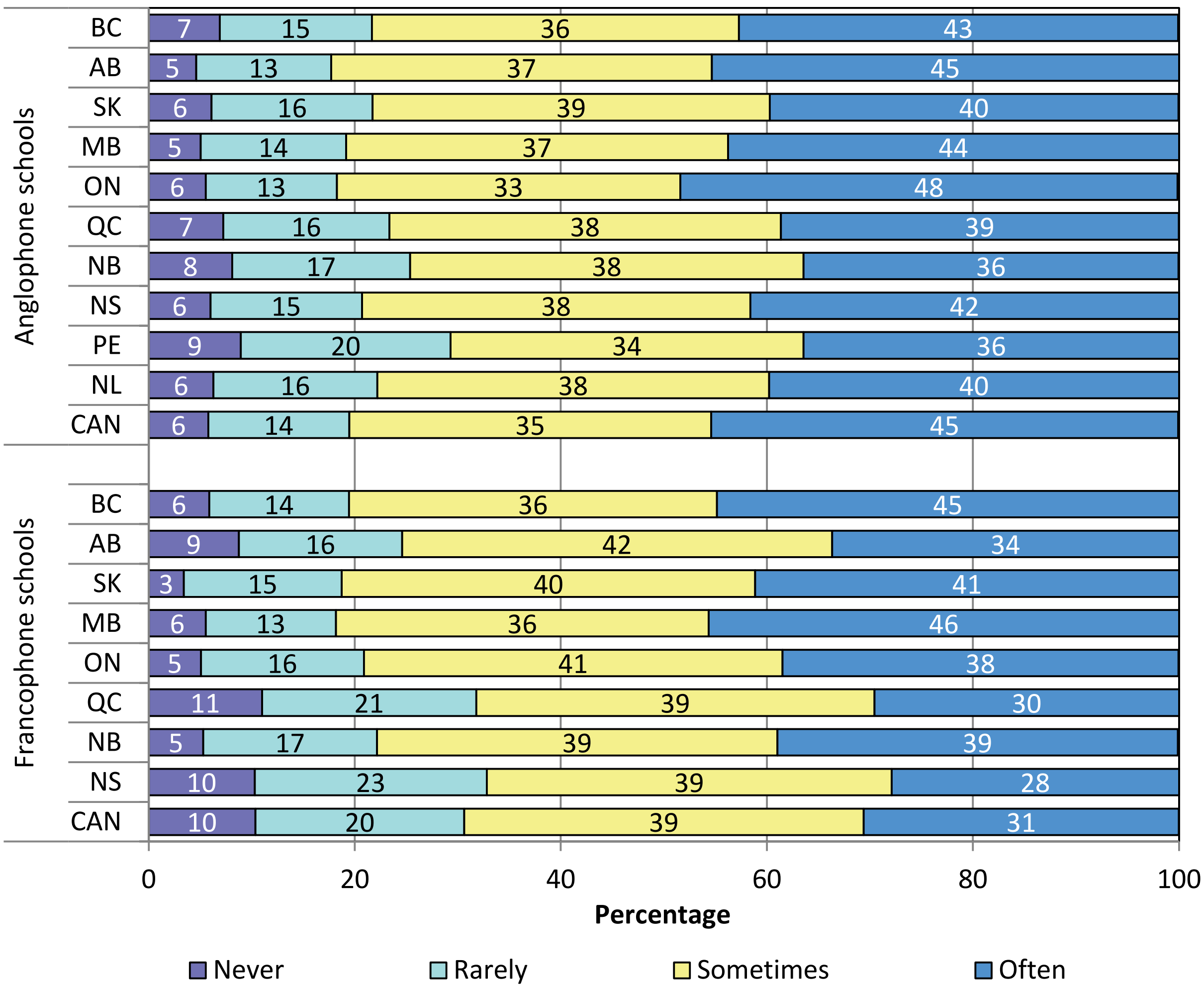


CHART 8.6 **Student reports of frequency of teachers providing feedback**



External assessments

Teachers were asked if the results of tests or assessments external to the school are used as part of the students' final grades. This is not a common practice for Grade 8/Secondary II science teachers, as chart 8.7 indicates, because fewer than 20 per cent of teachers in most jurisdictions use external assessments in this way. The high rate of negative responses to this question in part reflects the small number of jurisdictions that test at this grade level as part of provincial programs. The questionnaire did not ask specifically about Grade 8/Secondary II tests but more generally about external tests. For those teachers who do include such results in their grading practices, there is a negative association with achievement as chart 8.8 shows. This is inconsistent with the results reported in PCAP 2007 for reading which found no significant relationship between the use of external exams for grading and student performance (CMEC, 2009). A different approach was taken in PCAP 2010. Principals were asked whether external assessment results were discussed during meetings with staff or parents and if they were used to make instructional change. Although the use of external assessment results was not related to achievement in that study, principals with a more positive attitude about using provincial/territorial assessment results to inform instructional decisions tended to have higher mathematics scores in their schools (CMEC, 2012). Across Canada, reading and mathematics are more frequent topics than science for jurisdiction assessments at this grade level.

CHART 8.7 **Use of external test results as part of students' final grades**

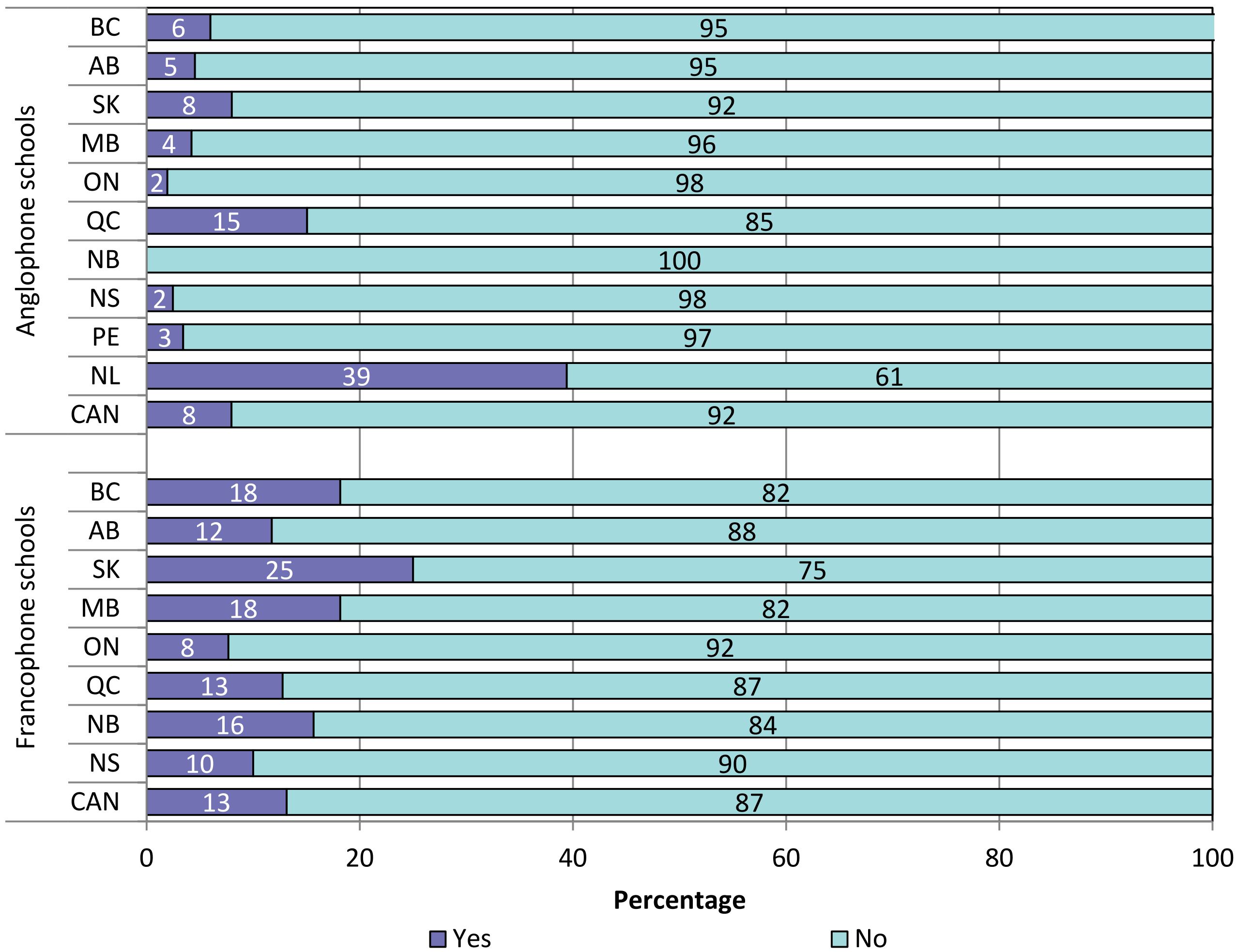
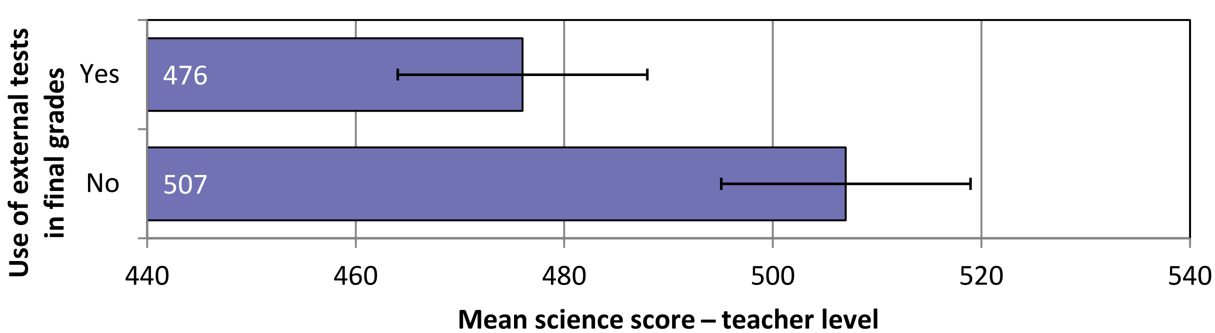


CHART 8.8 **Relationship between the use of external test results as part of students' final grades and science achievement**



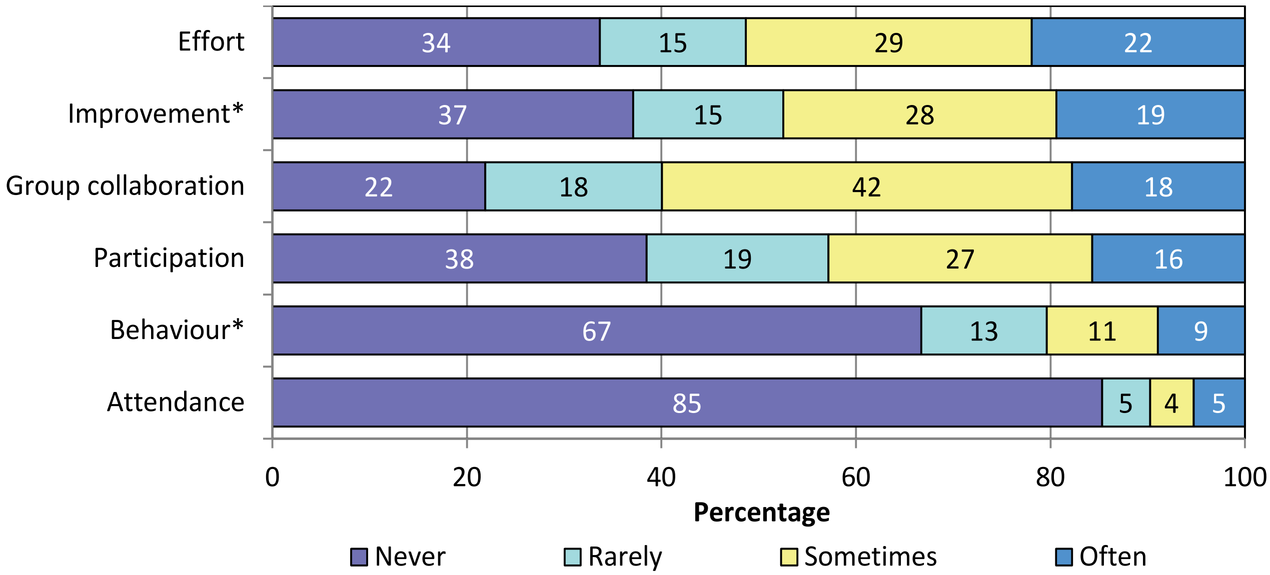
Non-academic criteria in grading

The interpretation and use of a grade is driven by how students, parents, and teachers value grades. For students who value high grades, parents and teachers can use this as a motivating factor in learning but it does little to motivate students who do not value this currency. Using grades for coercive power has been found to devalue the learning process and result in students more motivated by extrinsic rewards and the desire to avoid punishment rather than by the desire to learn (Pilcher, 1994). In a review of the literature conducted by McMillan and Workman (1998), the authors concluded that there is little empirical evidence of the specific effects of using particular assessment and grading practices. However, because teachers are concerned with student motivation, self-esteem, and the social consequences of giving grades, using student achievement as the sole criteria for determining grades is rare and, as Brookhart suggests (1991), grading often consists of a "hodgepodge" of attitude, effort, and achievement.

Teachers were asked to report the frequency that they use six non-academic criteria for grading. As the reader will see in chart 8.9, 22 per cent of Grade 8/Secondary II teachers report that they often take account of student effort when assigning grades. The least frequently used criterion for grading is attendance. Charts 8.10 and 8.11 present information on how frequently teachers assign grades for improvement and behaviour by population. Teachers in francophone schools in all jurisdictions report that they assign grades for these non-academic criteria far more frequently than those in anglophone schools. Teachers also report that grades are assigned for improvement more often than for behaviour.

Only two criteria are significantly related to achievement — grading for improvement and behaviour are both found to have a negative relationship with achievement in science (chart 8.12). The relationship between the number of these non-academic criteria used for grading and science achievement is shown in chart 8.13. The relationship is non-linear — the use of five or six of these criteria results in a significantly lower achievement when compared to not using such criteria for student grades. This is not consistent with the results for mathematics in PCAP 2010 that showed a linear pattern of reduced performance with increasing numbers of these non-academic criteria used (CMEC, 2012). This relationship does not imply causality because teachers may be grading in this manner in an attempt to change the behaviour of unmotivated or disinterested students.

CHART 8.9 **Frequency of the use of non-academic criteria in grading**



* significant relationship with science achievement

CHART 8.10 **Percentage of teachers assigning grades for non-academic criteria — improvement**

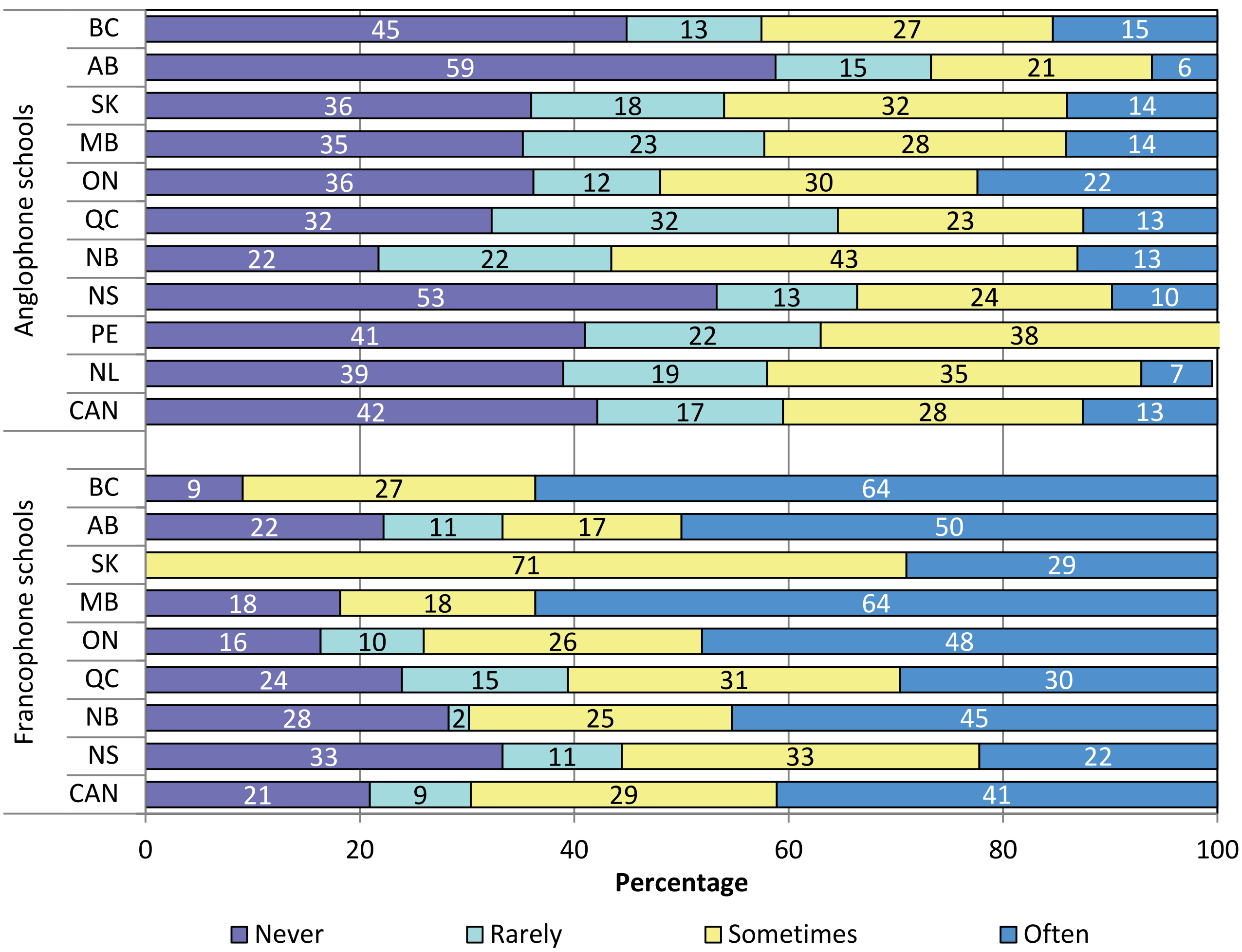


CHART 8.11 **Percentage of teachers assigning grades for non-academic criteria — behaviour**

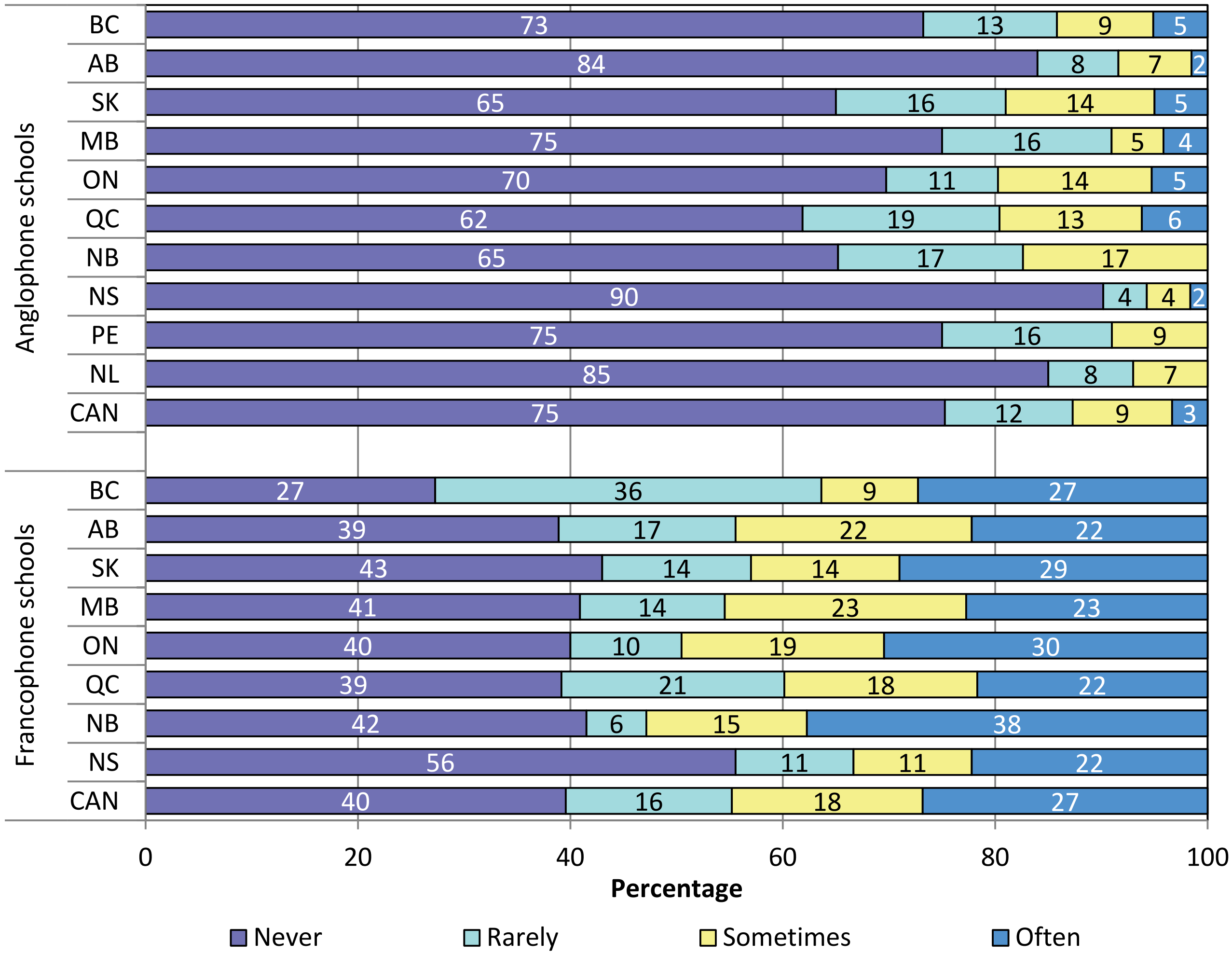


CHART 8.12 **Relationship between using non-academic criteria in grading and science achievement**

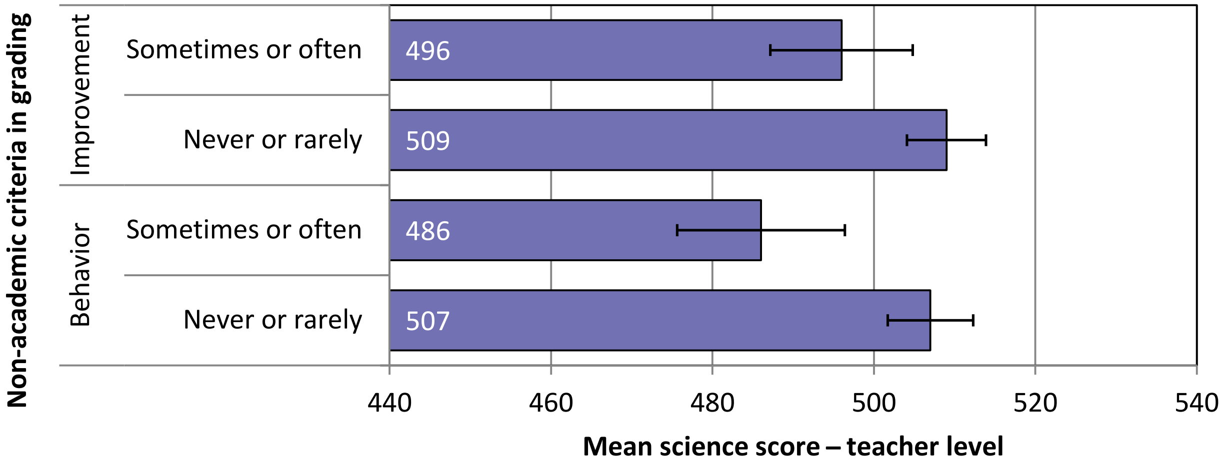
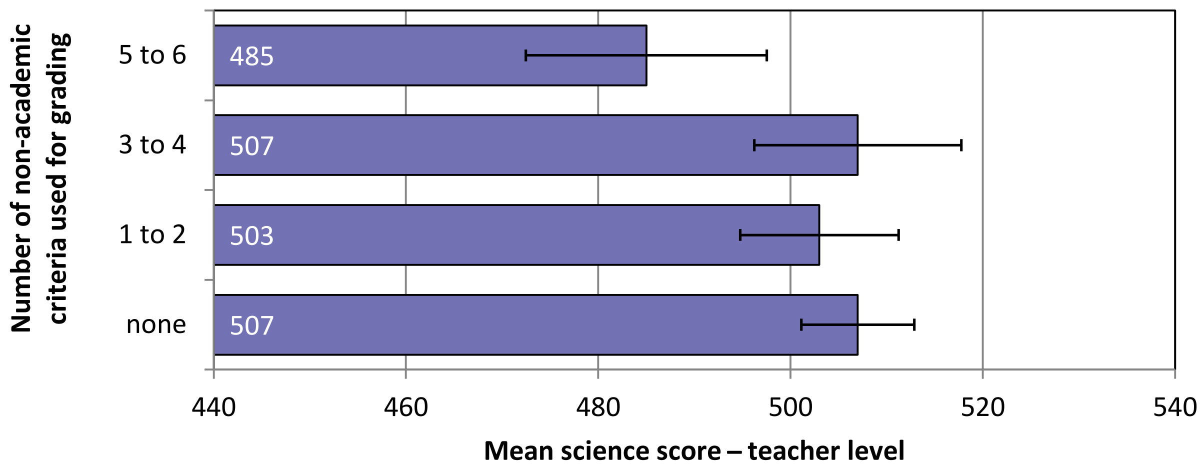


CHART 8.13 **Relationship between using increasing numbers of non-academic criteria in grading and science achievement**



Curricular accountability

The curriculum is the legal document mandated by the ministry of education in each jurisdiction. School principals were asked the extent to which science teachers are monitored with respect to teaching curriculum outcomes and the use of curriculum-related strategies and resources. As chart 8.14 presents, at least one-third of school principals report that they often hold their teachers accountable for the curriculum. This practice is positively related to achievement in science as chart 8.15 shows. Accountability for all four criteria is shown in table 8.5. Accountability monitoring is highest (61 per cent) for instructional and assessment strategies for francophone teachers in Alberta. The lowest proportion of teachers (less than 20 per cent) are monitored in francophone schools in Nova Scotia for curriculum outcomes and in British Columbia for instructional strategies and curriculum resources.

CHART 8.14 **Extent to which teachers are accountable for the curriculum**

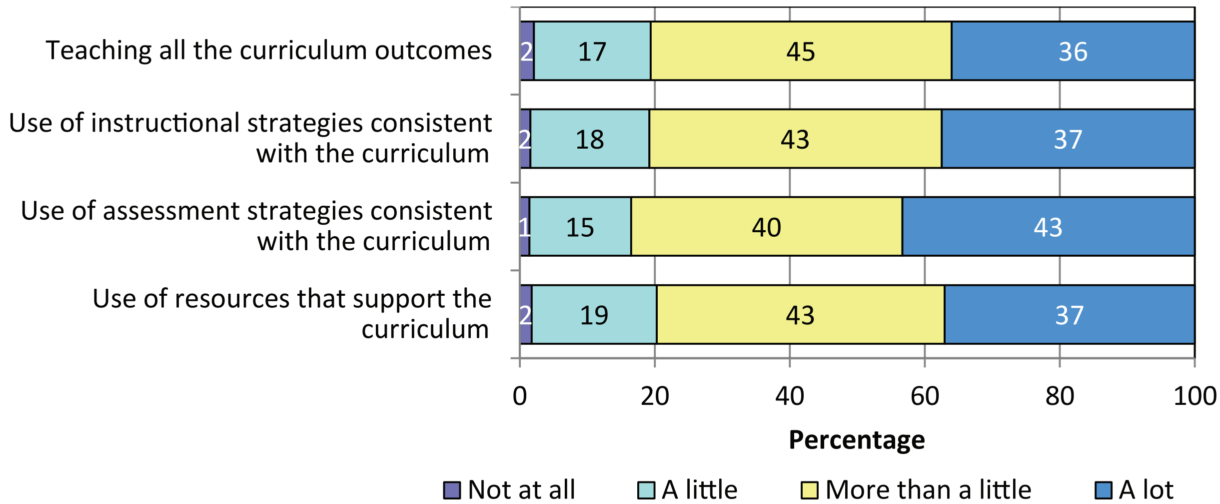


CHART 8.15 **Relationship between teachers' level of accountability for the curriculum and science achievement**

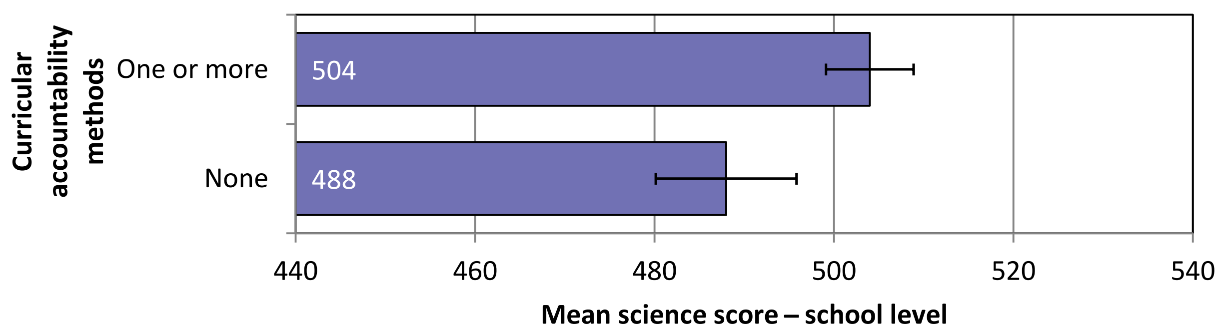


Table 8.5 **Percentage of teachers held accountable "a lot" for teaching curriculum outcomes and using strategies recommended in the curriculum**

	Curriculum outcomes	Instructional strategies	Assessment strategies	Curriculum resources
Anglophone schools				
BC	33	29	32	32
AB	42	44	50	43
SK	37	33	37	35
MB	27	34	46	32
ON	34	36	45	32
QC	33	34	34	28
NB	34	29	51	32
NS	37	43	44	40
PE	36	44	43	44
NL	27	31	28	26
CAN	**35**	**36**	**43**	**34**
Francophone schools				
BC	24	19	23	19
AB	46	61	61	47
SK	47	36	36	28
MB	52	31	56	38
ON	57	49	59	53
QC	28	34	40	34
NB	37	39	51	52
NS	14	59	30	51
CAN	**36**	**37**	**45**	**39**

Summary

This chapter explores assessment practices in schools and their relationship to achievement in science. Although Grade 8/Secondary II teachers in Canada use a variety of assessment methods, only the use of performance assessment is positively associated with achievement.

Students report that, to help them learn, their science teachers provide them with guidance regarding expectations both before completing their assignments in the form of rubrics and after the work is accomplished in the form of feedback. Of the two, only the provision of details about expectations in advance is associated with higher achievement. As previous PCAP administrations have shown, assigning grades for non-academic criteria is negatively associated with achievement.

Teachers use a variety of techniques to probe the level of student thinking during their learning. For example, overall in Canada, about half of all teachers report that they frequently ask their students to develop hypotheses and design investigations — activities that are important to enable students to come to an appreciation of what science is and how it is done in an authentic way. These activities are considered teacher-supported inquiry skills and are important in preparing students for more independent investigations in science.[34] Although the relationship with achievement was not significant for specific methods of assessing a student's level of understanding, the use of teacher-supported inquiry is positively associated with science performance.

Finally, monitoring the implementation of the curriculum, and the use of strategies and resources consistent with that curriculum, is positively associated with achievement in science.

[34] Refer to chapter 5 for a detailed discussion.

Excellence in education depends upon the motivation of students, quality and dedication of school personnel, parental support, characteristics of the school environment, and financial resources. Decisions at one level in a school system are affected by those made at other levels. Classroom-level decisions are influenced by school-level decisions which in turn are influenced by decisions related to resources, policies, and practices made at the school-district or even the provincial level. As the TIMSS 2011 survey reported, even parental decisions about school choice can influence a learning environment. Socioeconomically advantaged students attend the most successful schools and have access to better resources whereas students attending schools with disciplinary problems may experience difficulty with academic performance (Mullis et al., 2012a).

All schools experience challenges as they strive to provide the best educational opportunities possible for their students. However, from a national- and jurisdiction-level perspective, the quality of education in Canada is very high. According to a report relating jurisdictional profiles to achievement equity (CMEC, 2012), Canada has achieved both high performance levels and a relatively high degree of equity among students across jurisdictions. Unlike many countries that participate in the PISA survey, Canadian student performance is only weakly related to socioeconomic status (OECD, 2013).

This chapter examines three aspects of Canadian schools: demographic information, factors influencing learning, and challenges to teaching. Characteristics of the student body, which was the only category found to be significantly related to student achievement, are explored at the jurisdiction and population level. Although there was no strong correlation between the level of science performance and the challenges that school principals identified, this topic does help to identify the more frequently reported issues that schools have to manage to deliver high-quality education.[35]

Schools participating in PCAP

Across Canada, close to 1,600 schools participated in PCAP 2013. The sample of schools for PCAP was randomly selected from all schools with Grade 8/Secondary II under the purview of the ministry/department of education in each province. In two provinces, Prince Edward Island and Newfoundland, the two official language groups were combined because the number of schools was too small for separate statistical analysis. Students in French immersion programs were considered part of the anglophone population.

School demographics

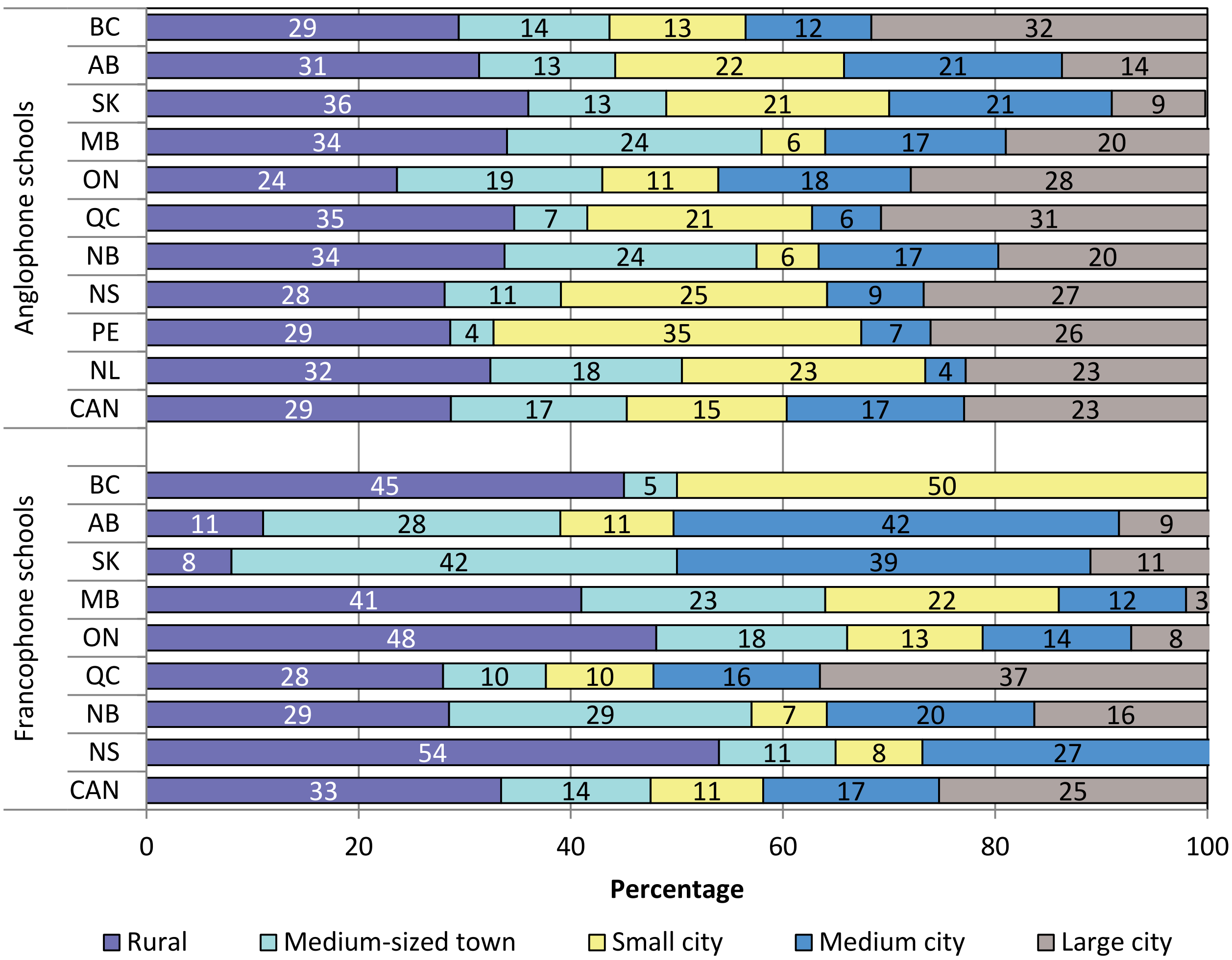
The schools participating in PCAP 2013 were located in communities ranging from rural settings to large cities. As chart 9.1 indicates, there is significant variation between populations.[36] Over 50 per cent of francophone schools were located in rural settings in Nova Scotia (54 per cent). At the other extreme, the highest proportion of schools located in large cities is found in anglophone schools in

[35] Previous chapters report other aspects of schools, including time management, assessment practices, and instruction climate.

[36] Totals in these charts may not sum to exactly 100 per cent because of rounding.

British Columbia (32 per cent) and in schools in both language systems in Quebec (anglophone — 31 per cent, francophone — 37 per cent).

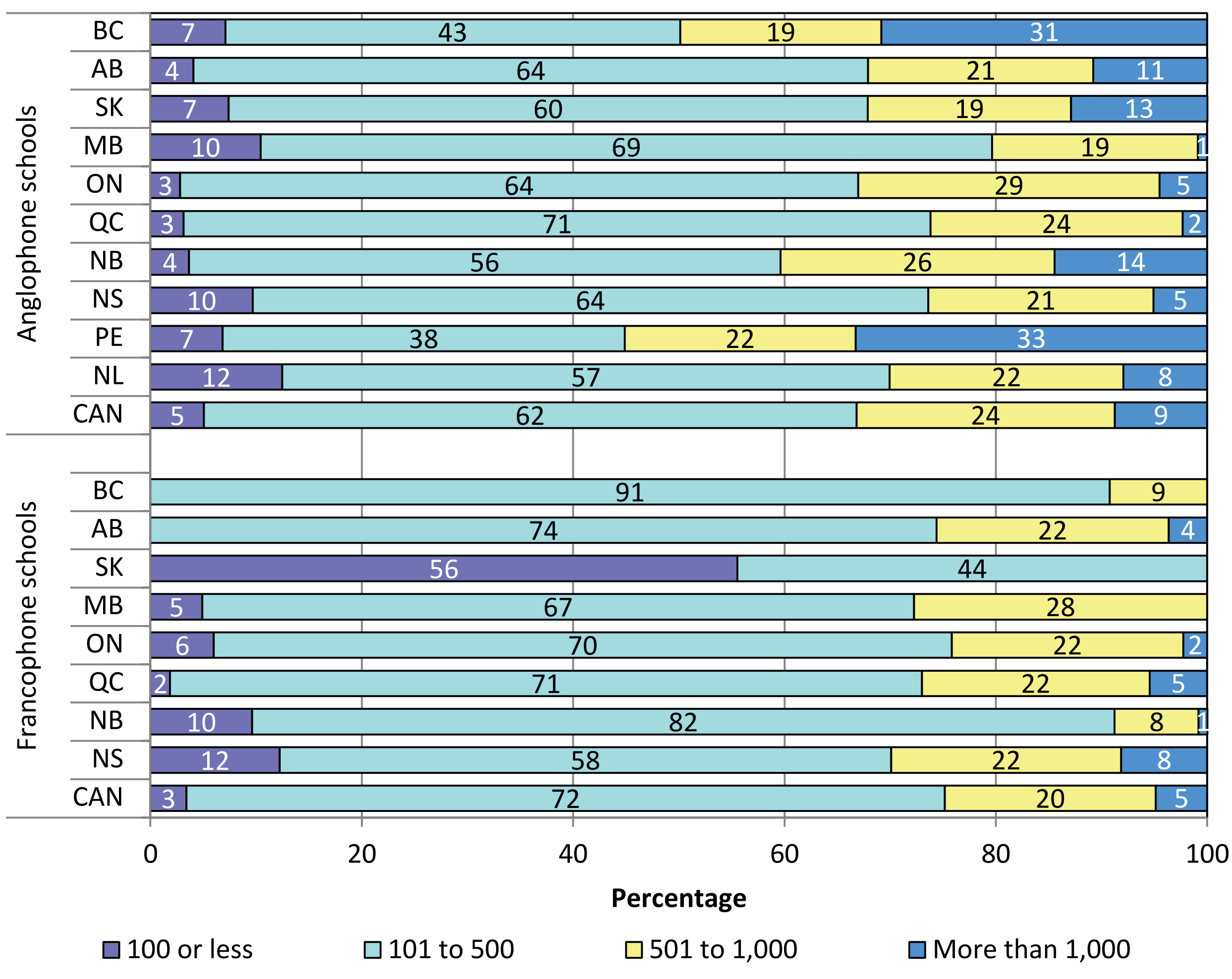
CHART 9.1 **Community sizes in which schools participating in PCAP were located**



The majority of schools that participated in PCAP 2013 were intermediate in size with enrolments of between 100 and 500 students. The largest proportion in this size range is in the francophone school system in British Columbia (91 per cent) and New Brunswick (82 per cent). The highest proportion of schools with small enrolments (that is, 100 or fewer students) is found in Newfoundland and Labrador (12 per cent) and in the francophone school systems in Saskatchewan (56 per cent) and Nova Scotia (12 per cent), whereas the highest proportion of schools with large enrolments (more than 1,000 students) is found in Prince Edward Island (33 per cent) and the anglophone school system in British Columbia (31 per cent), as shown in chart 9.2.

There has been much debate about the impact of school size on student learning and achievement. Many studies have reported that schools with fewer students have higher student achievement (e.g., Bidwell & Kasarda, 1998; Deller & Rudnicki, 1993; Walberg & Walberg, 1994) and are associated with fewer disciplinary problems and acts of vandalism (Huber, 1983). But because it relies on cross-sectional data that do not account for endogenous variations in school size, this analysis is often problematic. To overcome the issue with cross-sectional data, Kuziemko (2006) used a three-year longitudinal study and reported that smaller schools at the elementary level have a positive impact on both math scores and attendance rates. At the secondary level, Lee and Smith (1993) reported higher achievement in math, reading, history, and science in small schools compared to large schools but many other studies at this level are contradictory (Fowler & Walberg, 1991; Lee & Smith, 1993, 1995; Sander, 1993; Schreiber, 2002). The PCAP assessment results did not show a significant association between school size and academic achievement. This may be explained by the great variance in institution types and sizes that participating Grade 8/Secondary II students attend (e.g., elementary schools, junior high schools, or high schools) which may result in biases that are difficult to control.

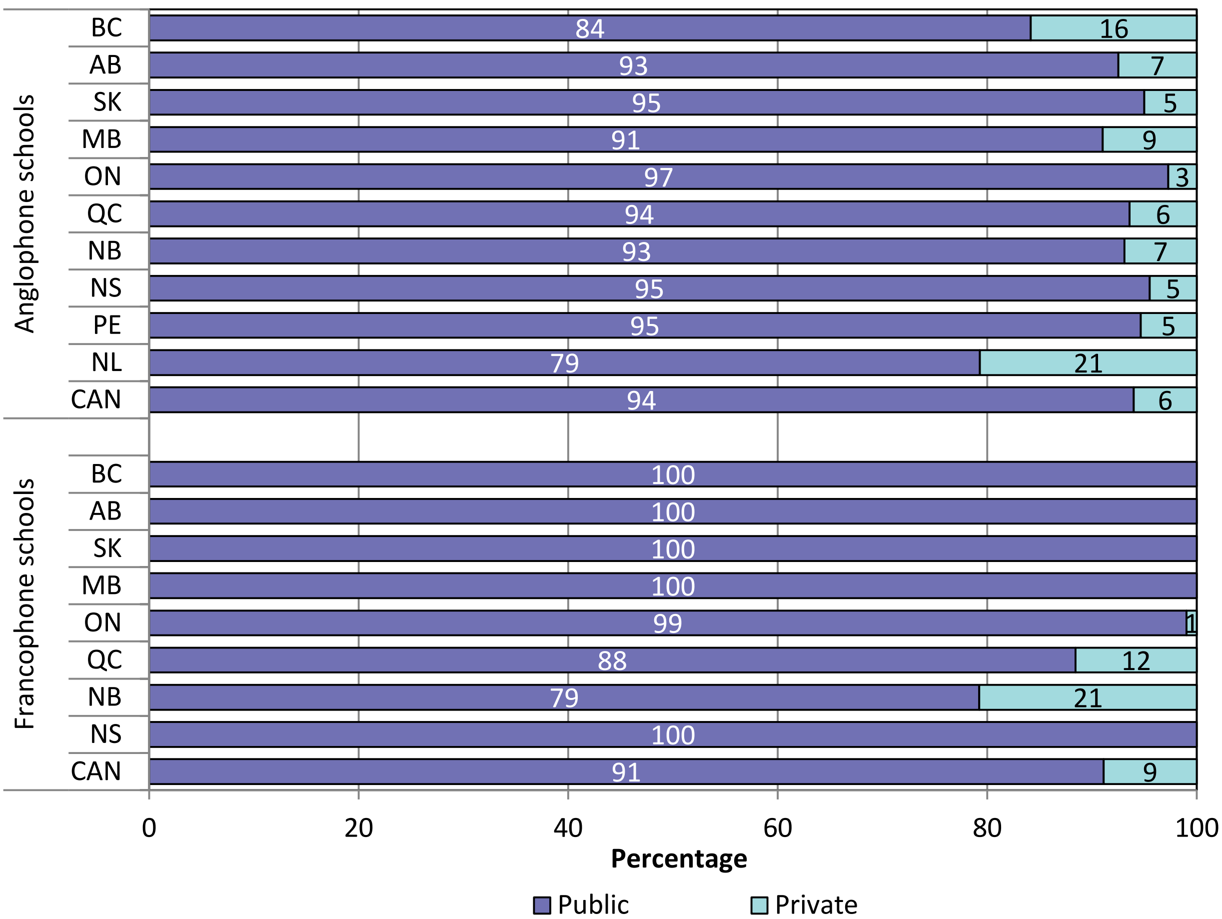
CHART 9.2 **Total student enrolment in schools participating in PCAP**



Within the sample of schools chosen to participate in PCAP 2013, there were schools under both public and private governance as chart 9.3 indicates. The proportion of public schools ranged from as low as 79 per cent in Newfoundland and Labrador and in the francophone school system in New Brunswick (and consequently the highest proportion of private schools) to 100 per cent of participating schools in the francophone school system in British Columbia, Alberta, Saskatchewan, Manitoba, and Nova Scotia. Although some research points to an advantage to private school education in the later years of schooling, such research is plagued with methodological issues that cause such conclusions to remain problematic (Goldhaber, 1999). The PCAP results confirm studies reporting that the choice of private versus public education does not significantly affect student learning (e.g., Witte, 1992; Willms, 1992) although such choices are often aligned with parents' socioeconomic and educational status (Goldhaber, 1999). Although schools consisting of more socioeconomically advantaged children typically result in school norms of positive attitudes toward school and higher academic aspirations and achievement, SES alone does not appear to explain differences in student achievement.

Achievement differences are often related to teacher attitudes and behaviours, parental involvement, and school structural characteristics (Edmonds & Fredericksen, 1979). *PISA 2009 Results: What Makes a School Successful* considered two additional organizational features of schools: the degree of autonomy for decisions related to resource allocation and curriculum and assessment design and the degree of school choice afforded to students and parents (OECD, 2010). Not all schools within the same governance system have the same level of discretion over their curricula, assessments, or resources.

CHART 9.3 **Proportion of public and private schools**

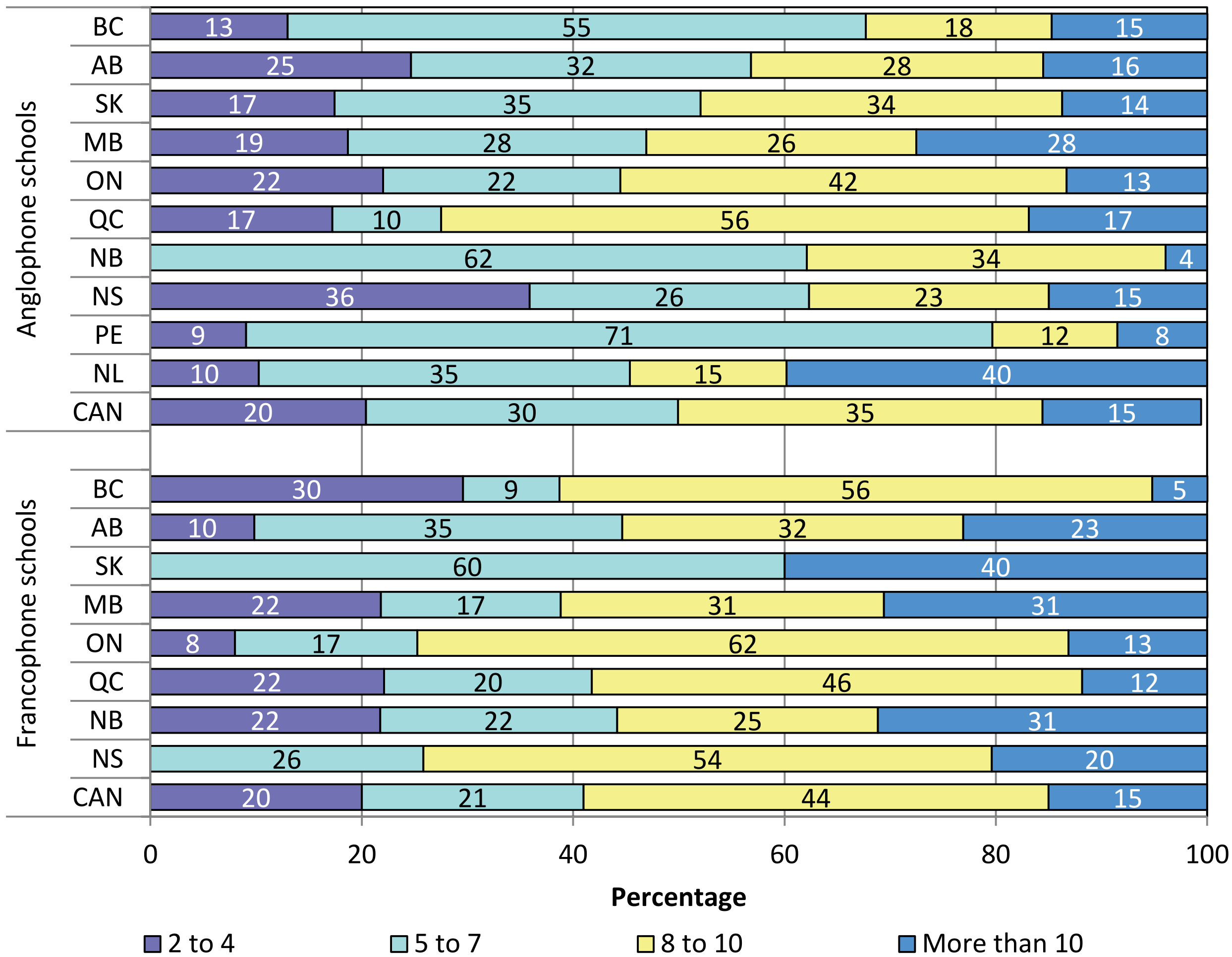


Grade configuration

Over the past century, grade-level configurations in schools have been in a constant state of flux — schools serving all grades have transitioned to self-contained junior high schools, and then back again. There is currently a push to merge junior high schools with their elementary counterparts to create kindergarten through eighth-grade schools (Schwartz, Stiefel, Rubenstein, & Zabel, 2011). Some studies have found that grade-level configuration can have an impact on student achievement. For example, Dhuey (2013) found poorer math and reading scores in middle schools compared to schools with both elementary and junior high students in British Columbia. She suggested that the smaller number of grades found in junior high schools might have an effect on school and cohort size. However, this is not consistent with the data in this study because no significant relationship was apparent between school enrolment and science achievement. Grade configuration determines the number of times a student will be forced to move to a new school and the age at which such transitions occur. In a study of 232 large, inner-city public schools in Michigan, students were found to perform better in schools with more grade levels but lower achievement was related to higher numbers of school transitions (Wren, 2004). In a study focused on rural or small-town schools, Alspaugh (1998) found students who transitioned to high school earlier (e.g., schools spanning Grades 7 to 12) were less likely to drop out than those who transitioned in later grades (e.g., high schools with a grade span of 10 to 12). Middle schools with transition programs targeting students, parents, and staff were able to mitigate the stressors associated with school transition and improve student achievement (Smith, 1997).

Principals were asked the number of grade levels that were taught in their schools. The range of grades reported was very broad but the pattern of responses identified a few common grade configurations. For example, more than 10 grades in a school could represent kindergarten to Grade 12, whereas two to four grades could represent a junior high school. Although there is wide variability across Canada, principals most commonly report having five to seven or eight to ten grades taught in their schools. Over 30 per cent of anglophone schools in Nova Scotia have two to four grades (chart 9.4). The highest proportion of schools with five to seven grades is found in Prince Edward Island (71 per cent). The highest proportion of schools with more than 10 grades is found in Newfoundland and Labrador and in francophone schools in Saskatchewan (40 per cent).

CHART 9.4 **Number of grade levels in schools participating in PCAP**



The number of grade levels in a school has an impact on the enrolment in Grade 8/Secondary II. Principals reported having from 25 or fewer to more than 200 students enrolled at this grade level as chart 9.5 shows. The largest enrolment numbers (more than 200 students) are reported for Prince Edward Island (32 per cent) and for anglophone schools in British Columba (27 per cent) and the smallest enrolment numbers (25 or fewer students) are reported in anglophone schools in Manitoba (41 per cent) and francophone schools in Saskatchewan and Nova Scotia (50 per cent).

The number of Grade 8/Secondary II classes are a function of enrolment. In most jurisdictions, at least 40 per cent of participating schools report teaching one or two classes at this grade level while about 40 per cent of schools in Prince Edward Island and British Columbia report five or more Grade 8/Secondary II classes as chart 9.6 presents.

CHART 9.5 **Grade 8/Secondary II student enrolment in schools participating in PCAP**

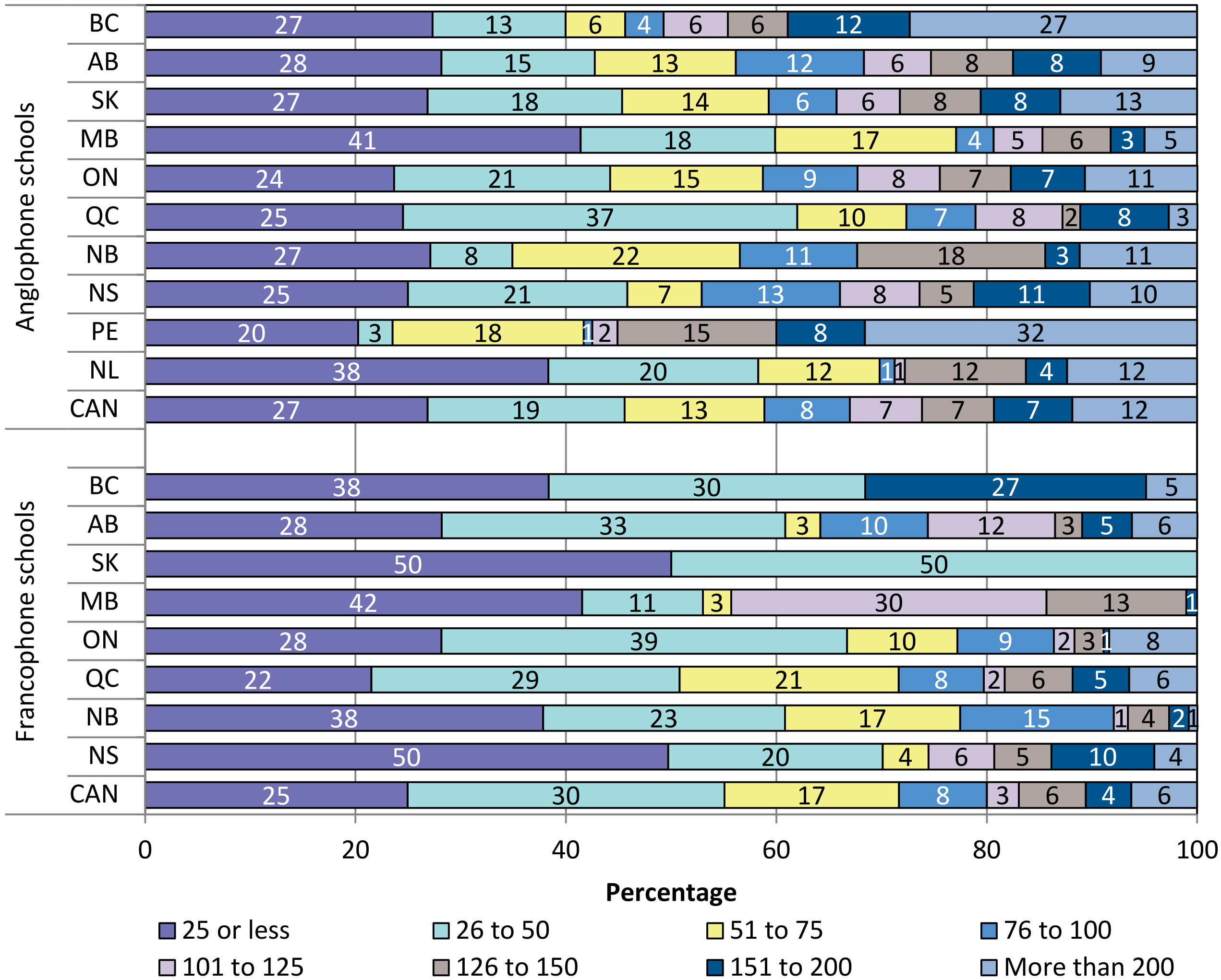
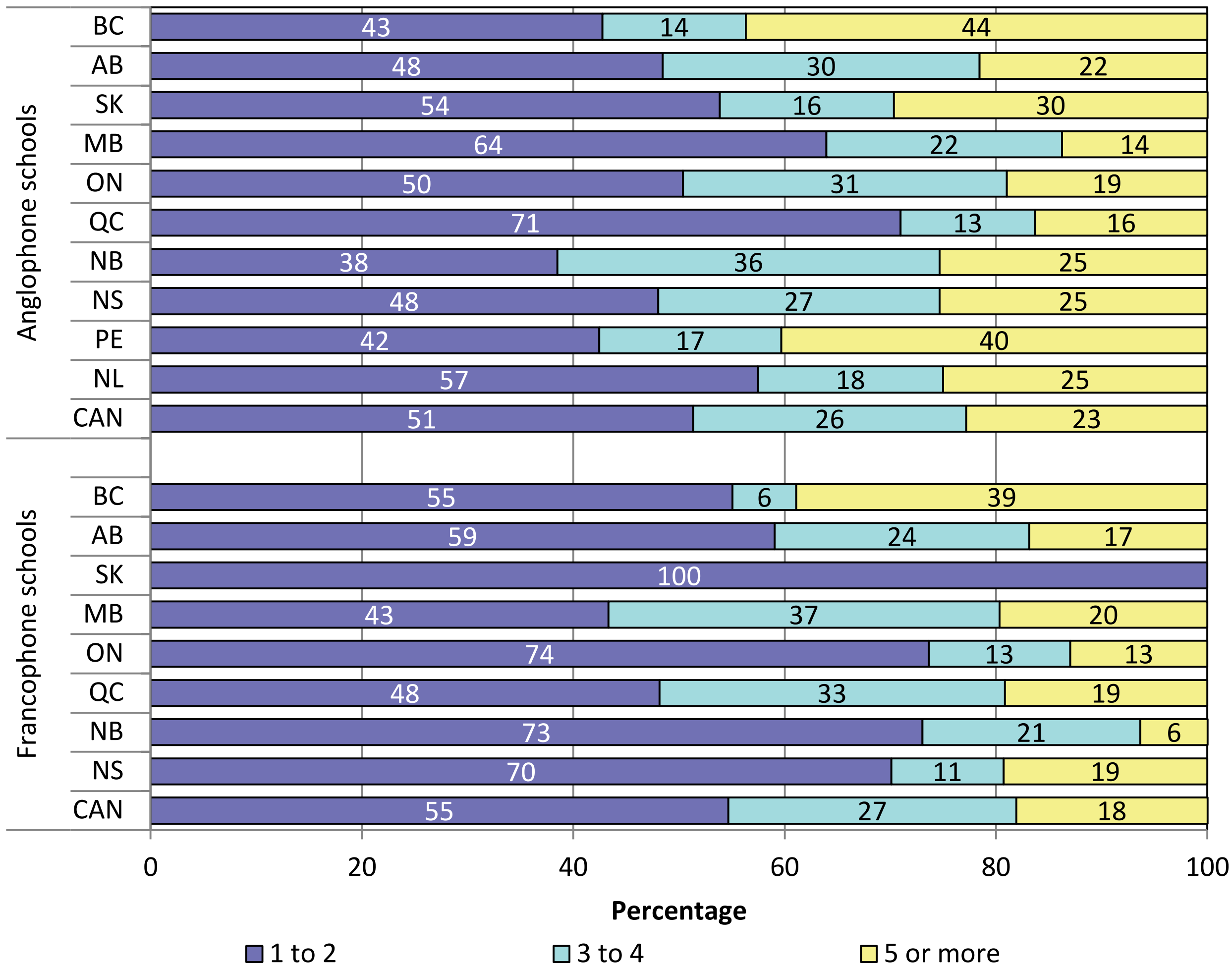


CHART 9.6 **Number of Grade 8/Secondary II classes in schools participating in PCAP**



Factors influencing learning

Schools commonly deal with two educational issues: quality and equity of education. Quality of education includes schooling outcomes such as school completion, academic performance, and students' attitudes and values. Equity emphasizes high achievement levels with the least disparity between the highest- and lowest-achieving students or groups. Major equity issues include gender differences, socioeconomic differences, and racial-ethnic differences. It may be easier for school administrators to focus on the educational quality in their school, particularly when they are held accountable for schooling outcomes. In fact, most school policies and practices, such as curriculum tracking and parental volunteering, directly target the quality of education, rather than the equity of education.

To elucidate factors that could influence learning in schools, school principals were asked to respond to the 13 items listed in table 9.1 using a conventional four-point scale from "not at all" to "a lot." At the school level, only two items show a significant impact on student achievement in science. Characteristics of the study body had a positive relationship with achievement; provincial and territorial assessment results that count toward students' final marks had a negative relationship with achievement.

TABLE 9.1 **Questionnaire items related to influences on student learning**

To what extent would you say that each of the following has an influence on your students' learning?
Provincial/territorial assessment results that count toward students' final marks
Results from classroom assessments
Provincial/territorial curriculum
Teachers within departments or subject groups
Individual teachers
Parent/guardian advisory committees or school councils
Characteristics of the student body
Students' voice or representation
Textbooks and textbook publishers
Access to resources
Teacher groups external to the school (e.g., district committees, professional associations)
External agencies (e.g., business community)
Church or religious groups

Principals were not asked about specific student-body characteristics that could influence learning, in part because the identification of such characteristics would be specific to both individual schools and classrooms. The results of the PCAP assessment are reported at only the jurisdiction and population level to ensure that it is not possible to identify individual schools, school districts, or students.

At the national level, student-body demographics have a similar degree of impact in the anglophone and francophone school systems. In most populations, principals report most frequently that such characteristics have more than a little influence on student learning. The proportion of principals reporting a high impact varies from 10 per cent in francophone schools in British Columbia to 40 per cent or more in Newfoundland and Labrador, in anglophone schools in New Brunswick, and in francophone schools in Alberta and New Brunswick (chart 9.7). Generally, science achievement was higher in schools where principals reported that student-body characteristics influence their students' learning more than a little or a lot, as chart 9.8 shows. This may imply that increasingly diverse schools may have a positive relationship with both quality and equity in education in Canada.

CHART 9.7 **Percentage of school principals reporting that student characteristics influence student learning**

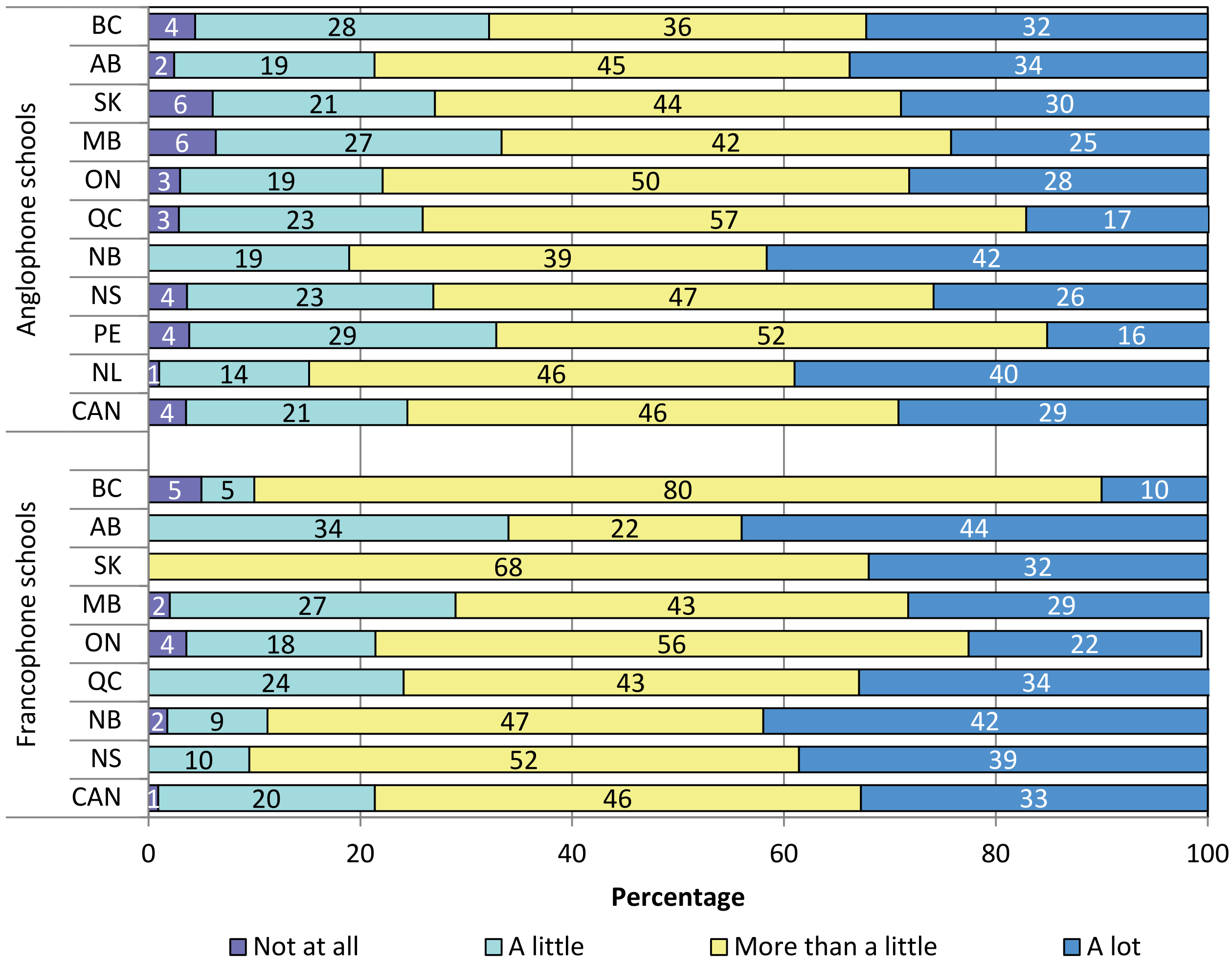
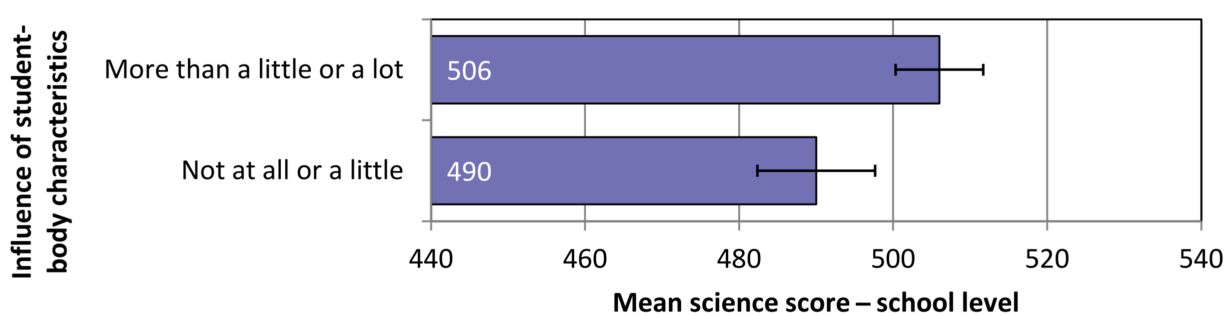


CHART 9.8 **Relationship between student characteristics and science achievement**



Diversity of student populations

Two indicators of school populations' diversity were included in the school questionnaire: the proportion of students in English or French second-language (ESL/FSL) programs and the proportion of students of Aboriginal identity in the school. Distributions for these two variables appear in charts 9.9 and 9.10.

School principals were asked to report the percentage of students in their schools who identified as English-as-a-second-language learners in anglophone schools and French-as-a-second-language learners in francophone schools (e.g., students who are or have been in special classes for those whose first language is not the school system's language). The acronyms *ESL* and *FSL* used here refer to students whose first language is different from the language of the school. Although these programs apply to Canadian families who send their children to schools in the official language other than their home language, they are often associated with immigrant students.

Francophone schools in British Columbia and Saskatchewan stand out as having the largest proportion of students in second-language programs — more than half of the student body are second-language learners in 18 per cent of British Columbia schools and 15 per cent of Saskatchewan schools. However, over half of francophone schools in Alberta, Saskatchewan, and Nova Scotia report having no students in these second-language programs. Generally, across jurisdictions, most principals report that their student body consists of between 1 and 5 per cent of students in second-language programs.

Principals were asked to report the percentage of students in their schools who identify themselves as Aboriginal (i.e., First Nations, Métis, or Inuit). The proportion of students of Aboriginal identity in publically funded schools in the PCAP sample of schools in most jurisdictions is relatively small with most principals reporting that their student body consists of 1 to 5 per cent Aboriginal students. However, in anglophone schools in Manitoba, Quebec, and New Brunswick and in francophone schools in Saskatchewan, Quebec, and New Brunswick, more than 10 per cent of principals reported that one-quarter or more of their students identified themselves as Aboriginal. It is important to note that federally funded schools do not participate in PCAP and only students of Aboriginal identity attending schools under provincial jurisdiction are reported here.

CHART 9.9 **Proportion of students identified as second-language learners in schools**

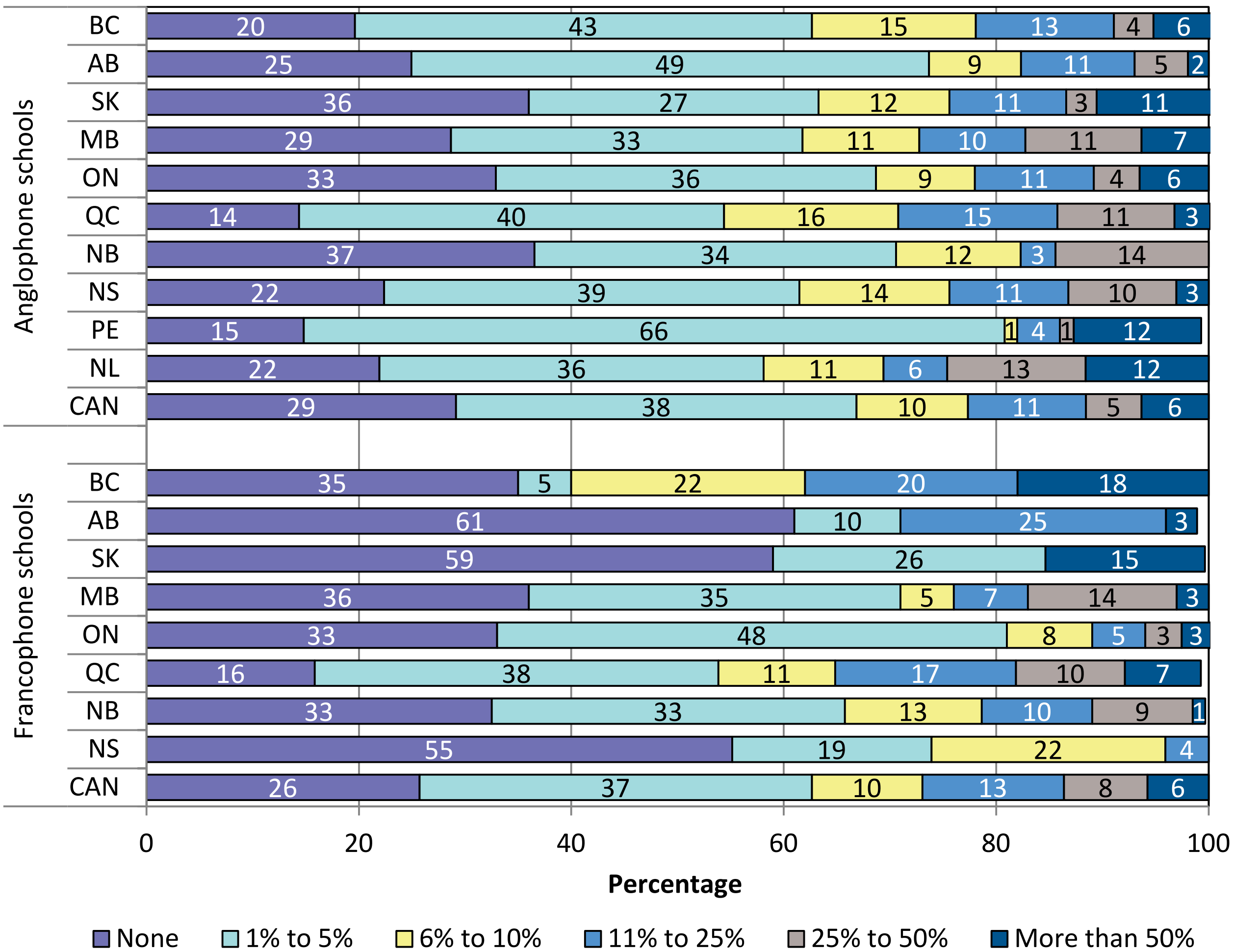
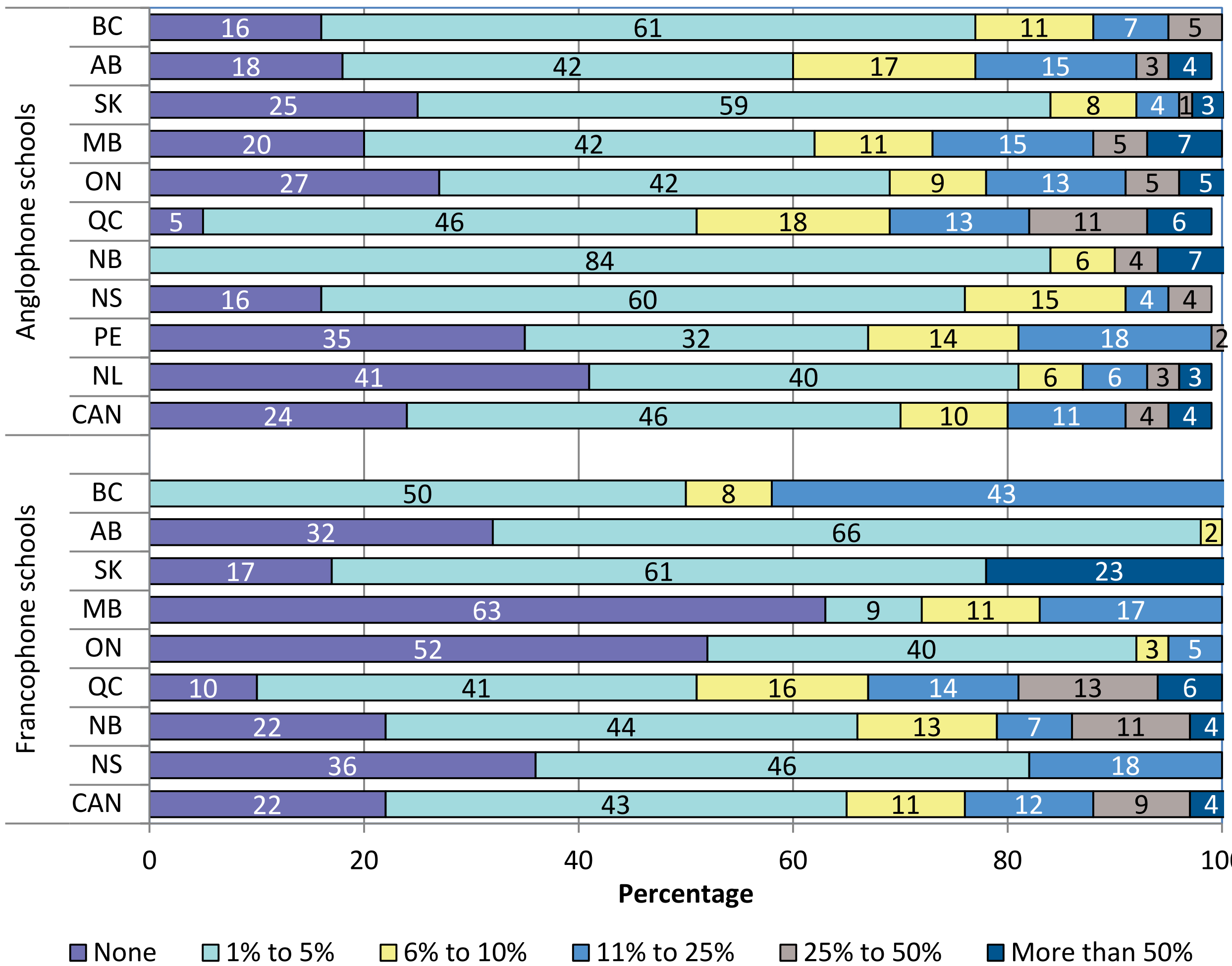
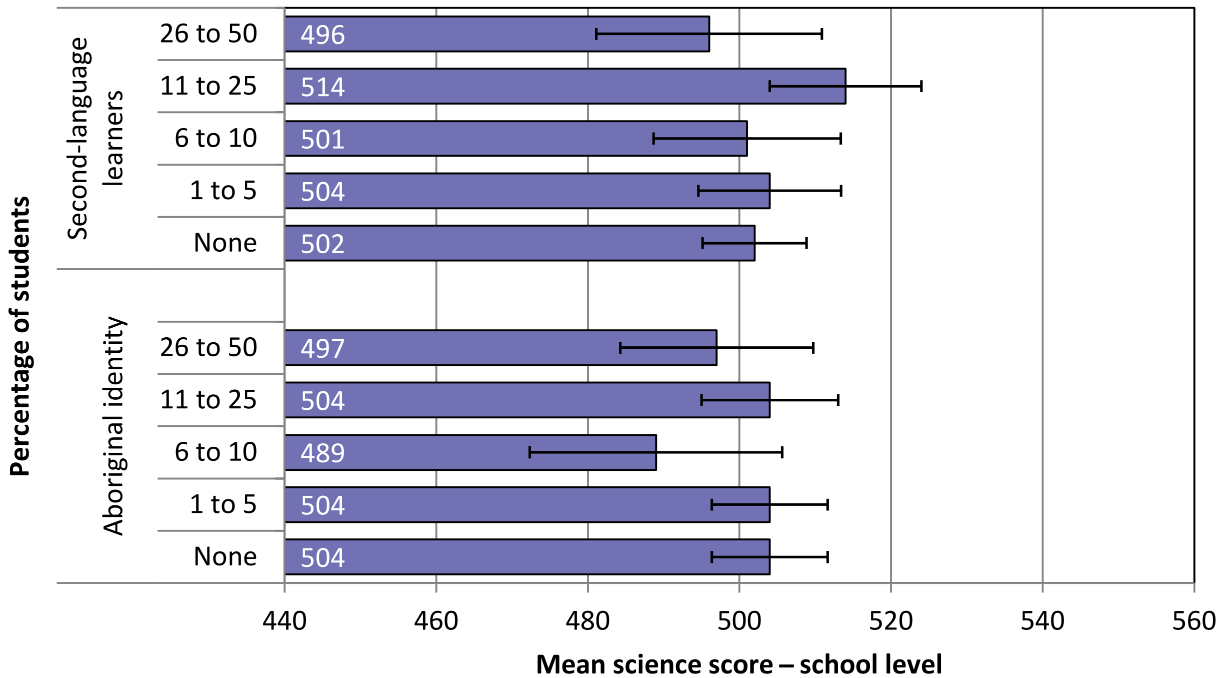


CHART 9.10 **Proportion of students of Aboriginal identity in schools**



The relationship between science achievement and the proportion of second-language learners and students of Aboriginal identity is non-linear for both variables as chart 9.11 presents. This is quite different from the results reported for mathematics in PCAP 2010 where there was a trend of decreasing achievement with increasing proportions in these two categories of students. This could mean that science is a much more accessible subject at this grade level for students who approach learning from more diverse backgrounds.

CHART 9.11 **Relationship between the proportion of second-language learners and Aboriginal students in schools and science achievement**

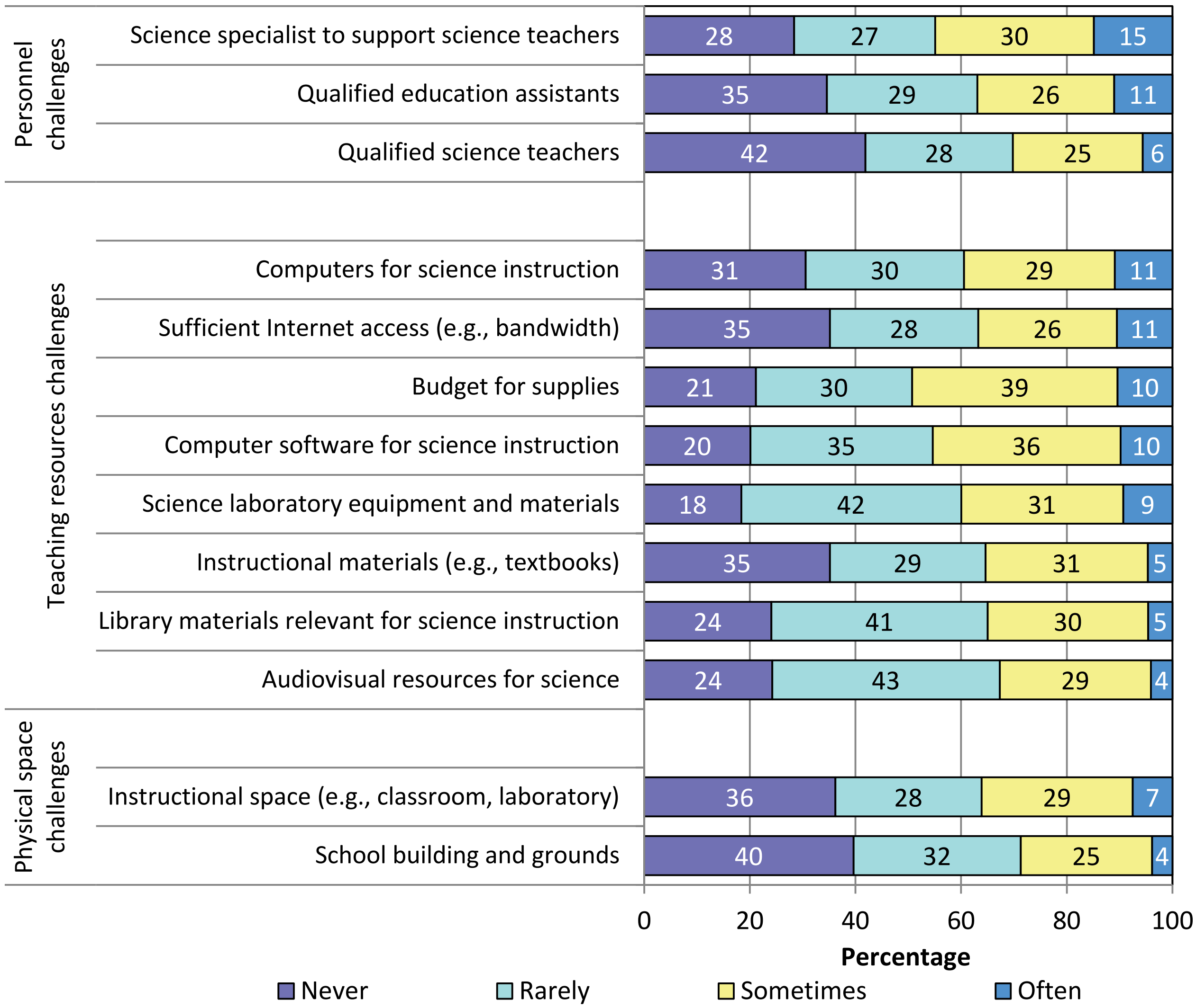


Challenges to learning

School principals were asked to give their opinions on what challenged their capacity to provide instruction in their schools. The series of 13 items gave rise to three categories of challenges related to personnel, teaching resources, and physical space. Although at the national and jurisdiction level, these challenges are not significantly associated with achievement in science, the impact at the local level bears further study.

The challenge that principals identified with the greatest frequency is access to science specialists to support their teachers. This is considered to "often" present a challenge in 15 per cent of schools and "sometimes" present a challenge in close to one-third of schools surveyed. Although over 60 per cent of anglophone teachers and over 50 per cent of francophone teachers in Canada consider themselves specialists in science by either education or experience (see chapter 5, table 5.2), many Grade 8/ Secondary II teachers are considered generalists which may account for the need for science specialists to support them in some aspects of their curricular knowledge. Having qualified science teachers in their schools is the challenge principals reported with the least frequency in this category. With respect to teaching resources, the budget for supplies provides a challenge sometimes or often in almost half of the schools sampled in PCAP and challenges related to computers or computer software for science instruction and, to a lesser extent, sufficient Internet access were also frequently reported by school principals. Close to one-third of schools in this study reported challenges related to physical space — either instructional space or the building and its grounds (chart 9.12).

CHART 9.12 **Challenges to learning reported by school principals**



A study by Levine and Lezotte (1990) identified a series of school characteristics that allowed for a productive or "effective" learning environment. They concluded that the presence of students with positive feelings about themselves as well as other students and teachers was an important characteristic of an effective school. Other characteristics found to be associated with effective schools were the maintenance of an orderly atmosphere, the promotion of school coherence, minimizing distractions to effective learning, ensuring that school leadership nurtures cooperative relationships among school members, and encouraging teachers and parents to be receptive and responsive to each other's needs (Levine & Lezotte, 1990). These characteristics, with respect to this study, are discussed in more detail in previous chapters.

Summary

The demographic information presented here helps to portray the incredible variability among schools across this country. Students participating in PCAP 2013 attended schools located in our largest cities and in small rural settings. The schools, which were both public and private, ranged in size from more than 1000 to fewer than 100 students, with as few as two to more than 10 different grade levels. The number of Grade 8/Secondary II students, the target population for this study, ranged from more than 200 to fewer than 25 students per school organized into between one and more than five classes, sometimes with two or more grade levels in the class. While this variability might seem challenging, the challenge that school principals reported most frequently is access to science specialists to support their teachers. Although they face challenges relating to personnel, teaching resources, and physical space, schools appear to remain focused on what is needed to provide quality education in science for their students.

Principals most frequently reported the student body's characteristics as an influence on learning in their schools. Although the school questionnaire items were designed to get a sense of the variability within schools, variables such as school and class size, grade configuration, governance, and proportion of second-language learners did not show significant relationships with science achievement. Further research is therefore needed to understand which characteristics principals believe influence learning in their schools. In a country that is proudly multicultural, every student body would be unique. Each embodies the variety of characteristics contributed by its individual students including race, religion, and cultural background, but also the shared learning experiences of the school community.

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