

## CHAPTER 3

# Sample Design in PIRLS 2021

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### Introduction

PIRLS is designed to provide valid and reliable measurement of trends in students' fourth-grade reading achievement in countries around the world, while keeping to a minimum the burden on schools, teachers, and students. The PIRLS program employs rigorous school and classroom sampling techniques so that achievement in the student population as a whole may be estimated accurately by assessing just a sample of students from a sample of schools.

PIRLS 2021 marks the beginning of the PIRLS transition to computer-based assessment, with countries having the option of administering the new computer-based version of the 2021 assessment, known as digitalPIRLS, or the paper-and-pencil version as in previous assessment cycles (paperPIRLS). Although the two versions were developed to be as similar in content as possible, inevitably there are some differences between them as a result of the two modes of administration. In order to control for mode differences while linking the two versions to the PIRLS assessment and to safeguard the measurement of trends from previous assessments, digitalPIRLS countries also provided a separate “bridge” sample. The bridge samples are separate, equivalent samples of students who were administered the paper version of the trend items (eight blocks of items that also were administered in 2016) during the main data collection. Thus, the bridge samples provided a bridge between the two assessment modes based on equivalent population linking.

The PIRLS assessment employs a two-stage random sample design, with a sample of schools drawn as a first stage and one or more intact classes of students selected from each of the sampled schools as a second stage. Intact classes of students are sampled rather than individuals from across the grade level, or of a certain age cohort, because PIRLS pays particular attention to students' curricular and instructional experiences, and these typically are organized on a classroom basis. Sampling intact classes also has the operational advantage of less disruption to the school's day-to-day operation than individual student sampling.

## National Sampling Plan

Each country participating in PIRLS needed a plan for defining its national target population and applying the PIRLS sampling methods to achieve a nationally representative sample of schools and students. The development and implementation of the national sampling plan was a collaborative effort involving the country's National Research Coordinator (NRC) and the PIRLS sampling experts.

Statistics Canada is responsible for advising the National Research Coordinators on all sampling matters and for ensuring that the national sampling plans conform to the PIRLS standards. In cooperation with sampling staff from IEA Hamburg, Statistics Canada works with the National Research Coordinators to select the national school samples and produce all supporting documentation for tracking the sampled schools. This includes ensuring that the school sampling frames (the school population list from which the school sample is drawn) provided by the National Research Coordinators are complete and satisfactory; checking that categories of excluded students are clearly defined, justified, and kept to a minimum; assisting the National Research Coordinators in determining the sample sizes and stratification plans that will meet both international and national objectives; and drawing national samples of schools. When sampling has been completed and all data collected, Statistics Canada documents population coverage and exclusions, school and student participation rates, and constructs appropriate sampling weights for use in analyzing and reporting the results.

The TIMSS & PIRLS International Study Center, in cooperation with Statistics Canada and IEA Hamburg, provides National Research Coordinators with a series of manuals to guide them through the sampling process. More specifically, *PIRLS 2021 Survey Operations Procedures Unit 1: Sampling Schools and Obtaining their Cooperation* describes the steps involved in defining the national target population and selecting the school sample, and *PIRLS 2021 Survey Operations Procedures Unit 3: Contacting Schools and Sampling Classes for Data Collection* describes the procedure for sampling classes within the sampled schools and making preparations for conducting the assessments. More information on the Survey Operations Units can be found in [Chapter 4](#) of this volume.

The PIRLS National Research Coordinators are responsible for providing Statistics Canada with all information and documentation necessary to conduct the national sampling, and for conducting all sampling operations in their country. In particular, the NRCs are expected to identify the grade that corresponds to the international target population; create a sampling frame by listing all schools in the population that have classes with students in the target grade; determine national population coverage and exclusions, in accordance with the PIRLS international guidelines; work with Statistics Canada to develop a national sampling plan and identify suitable stratification variables, ensuring that these variables are present and correct for all schools; contact all sampled schools and secure their participation; keep track of school participation and the use

of replacement schools; and conduct all within-school sampling of classes. As described in this chapter, each NRC is required to complete a series of sampling forms documenting the completion of each of these tasks.

A vital feature of each international meeting of National Research Coordinators is one-on-one meetings between each NRC and sampling staff at Statistics Canada and IEA Hamburg. At these meetings, each step of the sampling process is documented and reviewed in detail, and NRCs have the opportunity to raise issues and ask questions about their national situation and any challenges they face. Statistics Canada consults with the TIMSS & PIRLS International Study Center and the International Sampling Referee, as necessary, to resolve issues and questions. Final approval of PIRLS national sampling plans is the responsibility of the TIMSS & PIRLS International Study Center, based upon the advice of Statistics Canada and the International Sampling Referee.

## Defining the Target Population

As an international study of the comparative effects of education on student achievement in reading literacy, PIRLS defines its international target population in terms of the amount of schooling students have received. The number of years of formal schooling is the basis of comparison among participating countries. Thus, the PIRLS international target population is all students in their fourth year of formal schooling. UNESCO's International Standard Classification of Education (ISCED) 2011 (UNESCO, 2012) provides an internationally accepted classification scheme for describing levels of schooling across countries. The ISCED system describes the full range of schooling, from pre-primary (Level 0) to the doctoral level (Level 8). ISCED Level 1 corresponds to primary education or the first stage of basic education. The first year of Level 1 "coincides with the transition point in an education system where systematic teaching and learning in reading, writing and mathematics begins" (UNESCO, 2012, p. 30). Four years after this would be the target grade for PIRLS, and is the fourth grade in most countries. However, given the cognitive demands of the assessments, PIRLS wants to avoid assessing very young students. Thus, PIRLS recommends assessing the next higher grade (i.e., fifth grade) if the average age at the time of testing would be less than 9.5 years.

The PIRLS target population of students is defined as follows:

All students enrolled in the grade that represents four years of schooling counting from the first year of ISCED Level 1, providing the mean age at the time of testing is at least 9.5 years.

All students enrolled in the target grade, regardless of their age, belong to the international target population and should be eligible to participate in PIRLS. Because students are sampled in two stages, first by randomly selecting a school and then randomly selecting a class from within the school, it is necessary to identify all schools in which eligible students are enrolled. Essentially,

eligible schools for PIRLS are those that have any students enrolled in the target grade, regardless of type of school. All schools of all educational sub-systems that have students learning full-time in the target grade are part of the international target population, including schools that are not under the authority of the national Ministry of Education.

### National Target Population

For most countries, the target grade for PIRLS is the fourth grade. However, because educational systems vary in structure and in policies and practices with regard to age of starting school and promotion and retention, there are differences across countries in how the target grade is labelled and in the average age of students. To ensure that the appropriate national target grade is selected, each NRC completes Sampling Form 1, which identifies the target grade, the country's name for the grade, and the average age of students in that grade at the time of data collection. An example of a completed Sampling Form 1 is presented in Exhibit 3.1.

There are countries where students in the fifth or sixth grade are more likely to have developed the reading competencies necessary for success on the PIRLS fourth grade assessment. Such countries may choose to participate in PIRLS at either the fifth or sixth grade, instead of or in addition to the fourth grade, and are labeled accordingly in the PIRLS reporting.

**Exhibit 3.1: Example of Sampling Form 1**

Sampling Form 1		General Information	
<i>See Section 2 of PIRLS 2021 Survey Operations Procedures Unit 1</i>			
<b>PIRLS 2021 Participant :</b>	<i>Country X</i>		
<b>National Research Coordinator :</b>	<i>Firstname Lastname</i>		
1. Please indicate the assessment(s) in which your country plans to participate along with the target grade(s), name(s), and expected average age of students at the time of testing:			
Target Grade	Name of the Target Grade	Average Age	Assessment and Mode
<i>4</i>	<i>Primary 4</i>	<i>9.7</i>	<i>digitalPIRLS (with ePIRLS)</i>
			<i>Please select</i>
			<i>Please select</i>
2. Specify the usual start and end date(s) of the school year and the expected date(s) of testing for the field test and data collection.			
	Start of school year: <i>(DD-MM-YYYY)</i>	End of school year: <i>(DD-MM-YYYY)</i>	Expected Testing Period
<b>Field Test</b>	<i>01/09/2019</i>	<i>21/06/2020</i>	<i>April 1-15, 2020</i>
<b>Data Collection</b>	<i>01/09/2020</i>	<i>21/06/2021</i>	<i>April 1-30, 2021</i>
4. Specify the language(s) in which the assessment will be administered.			
<i>English</i>			
5. Describe the grade structure through ISCED Level 1 (primary education or the first stage of basic education) and ISCED Level 2 (basic or lower secondary education) in your country.			
<i>Grades 1 to 6, Primary schools</i>			
<i>Primary and lower secondary education are generally found in the same schools. Some schools also offer only primary education</i>			
6. Describe the age and birth date rules for entering ISCED Level 1 in your country.			
<i>Children must enter school (grade 1) in the autumn of the year in which they have their sixth birthday</i>			

## National Coverage and Exclusions

PIRLS is designed to describe and summarize student achievement across the entire target grade, and so it is important that the national target population aims for comprehensive coverage of all eligible students. However, in some cases, political, organizational, or operational factors make complete national coverage difficult to attain. Thus, in some unusual situations, certain groups of schools and students may have to be excluded from the national target population. For example, it may be that a particular geographical region, educational sub-system, or language group cannot be covered. Such exclusion of schools and students from the target population is referred to either as reduced population coverage, or exclusion. Sizeable and structural exclusions can be reported as reduced population coverage. Smaller exclusions are likely to be referred to as exclusions, as described below, to the extent they do not exceed acceptable exclusion levels.

Occasionally, countries with expected complete population coverage find it necessary to exclude at least some students from the target population because they attend very small schools, have intellectual or functional disabilities, or are non-native language speakers. Such students may be excluded at the school level (i.e., the whole school is excluded) or within the school on an individual basis.

**School Level Exclusions.** Although it is expected that very few schools will be excluded from the national target population, NRCs are permitted to exclude schools on the following grounds when they consider it necessary:

- Inaccessibility due to their geographically remote location
- Extremely small size (e.g., four or fewer students in the target grade)
- Offering a grade structure, or curriculum, radically different from the mainstream educational system
- Providing instruction solely to students in the student-level exclusion categories listed below (e.g., catering only to special needs students)

**Student Level Exclusions.** The international within-school exclusion rules are specified as follows:

- Students with functional disabilities — These are students who have physical disabilities such that they cannot perform in the PIRLS testing situation. Students with functional disabilities who are able to perform should be included in the testing.
- Students with learning disabilities — These are students who are considered, in the professional opinion of the school principal, or by other qualified staff members, to have learning disabilities or who have been tested as such. This includes students who are emotionally or intellectually unable to follow the general instructions of the test. Students should not be excluded solely because of poor academic performance or normal disciplinary problems. It should be noted that students with dyslexia, or other such

learning disabilities, should be accommodated in the test situation if possible, rather than excluded.

- Non-native language speakers — These are students who are unable to read or speak the language(s) of the test and would be unable to overcome the language barrier in the test situation. Typically, a student who has received less than one year of instruction in the language(s) of the test should be excluded.

Because disability criteria vary from country to country, NRCs are asked to translate the PIRLS international exclusion standards into the local equivalent. Students should be considered for exclusion strictly in accordance with the international standards. If a sampled school contains a class consisting entirely of students from one of the exclusion categories, such a class is excluded prior to classroom sampling.

NRCs understand that exclusion rates must be kept to a minimum in order that national samples accurately represent the national target population. Requirements for exclusion rates include the following:

- The overall number of excluded students must not account for more than 5 percent of the national target population of students in a country. The overall number includes both school-level and within-school exclusions.
- The number of students excluded because they attend very small schools must not account for more than 2 percent of the national target population of students.

To document population coverage and exclusions, each NRC completes Sampling Form 2, which lists the number of students in the national target population and the number of students excluded at both the school level and student level. An example of a completed Sampling Form 2 is presented in Exhibit 3.2.

**Exhibit 3.2: Example of Sampling Form 2**

Sampling Form 2		Coverage and Exclusions	
<i>See Section 3 of PIRLS 2021 Survey Operations Procedures Unit 1</i>			
<b>PIRLS 2021 Participant :</b>		Country X	
1. This Sampling Form refers to:		digitalPIRLS (with ePIRLS)	
Total enrollment in the target grade:		<b>Number of schools</b>	<b>Number of students</b>
[ a ]		822	56,560
2. School-level exclusions (if applicable):			
<b>Description of exclusions</b>		<b>Number of schools</b>	<b>Number of students</b>
1.	Students taught in languages other than English	8	630
2.	Special education schools	16	325
3.	Very small schools (less than 4 students in Grade 4)	40	110
4.			
5.			
TOTAL: (Sum of exclusions - Calculated automatically)		[ b ]	64
<b>Percentage of school-level exclusions:</b>		<b>schools</b>	<b>students</b>
( Box [ b ] ÷ Box [ a ] x 100 )		[ 1 ]	7.8%
3. Total enrollment after school-level exclusions:		[ c ]	758
( Box [ c ] = Box [ a ] - Box [ b ] )			55,495
		<i>Totals and percentages calculated automatically</i>	
4. Within-school exclusions (if applicable):			
<b>Description of exclusions</b>		<b>Number of students</b>	
1.	Students with special education needs (based on PIRLS 2016)	640	
2.			
3.			
TOTAL: (Sum of exclusions - Calculated automatically)		[ d ]	640
<b>Expected percentage of within-school exclusions:</b>		<b>schools</b>	<b>students</b>
( Box [ d ] ÷ Box [ c ] x 100 )		[ 2 ]	0.0%
5. <b>Expected percentage of reduced coverage and exclusions:</b>			7.8%
( Box [ 1 ] + ( 1 - Box [ 1 ] ) X Box [ 2 ] )			3.0%
		<i>Totals and percentages calculated automatically</i>	
6. Total enrollment in the target grade in previous school years.		<b>Years</b>	<b>Number of schools</b>
			<b>Number of students</b>
		2017/2018	856
		2016/2017	890
			58,451
			61,489

## Requirements for Sampling the Target Population

PIRLS sets high standards for sampling precision, coverage and exclusion rates, participation rates, and sample implementation in order to achieve national samples of the highest quality and survey estimates that are accurate, reliable, and internationally comparable.

### Sampling Precision and Sample Size

Because PIRLS is fundamentally a study of student achievement, the precision of estimates of student achievement is of primary importance. To meet the PIRLS standards for sampling precision, national student samples should provide for a standard error no greater than 0.035 standard deviation units for the country's mean achievement. This standard error corresponds to a 95% confidence interval of  $\pm 7$  score points for the achievement mean and of  $\pm 10$  score points for the difference of achievement means between successive cycles (e.g., the difference in a country's achievement mean between PIRLS 2016 and PIRLS 2021).<sup>1</sup> Sample estimates of any student-level percentage estimate (e.g., a student background characteristic) should have a confidence interval of  $\pm 3.5\%$ .

For most countries, the PIRLS precision requirements are met with a school sample of 150 schools and a student sample of 4,000 students. Depending on the average class size in the country, one class from each sampled school may be sufficient to achieve the desired student sample size. For example, if the average class size in a country is 27 students, a single class from each of 150 schools would provide a sample of 4,050 students (assuming full participation by schools and students). Some countries choose to sample more than one class per school, either to increase the size of the student sample or to provide better estimates of school-level effects.

Countries transitioning to digitalPIRLS required a sample size increase of 1,000 students to accommodate the addition of the ePIRLS material in the computer-based administration, thus raising their minimum sample size requirement to 5,000 students. They also required an additional sample of at least 1,500 students for the bridge data collection. This bridge sample was obtained by either selecting one additional class from a subset of the sampled schools, selecting a distinct sample of schools, or a combination of both strategies. The most suitable approach was developed with the sampling experts from Statistics Canada during the sampling development stage.

A school sample larger than the minimum of 150 schools may be required under the following circumstances:

- The average class size in a country is so small that, even when sampling more than one classroom per school, it is not possible to reach the student sample size requirements by selecting only 150 schools.

<sup>1</sup> The PIRLS achievement scale was established in 2001 based on the combined achievement distribution of all countries that participated in PIRLS 2001. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution in 2001. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of that distribution.

- Previous PIRLS assessments showed that the sampling precision requirements cannot be met unless a larger school sample is selected.
- Classes within schools are tracked by student performance. This increases variation between classes and can reduce sampling precision in student achievement. In this situation, it is advisable to sample at least two classrooms per school whenever possible, in addition to sampling more schools.
- A high level of non-response is anticipated, leading to sample attrition and reduced sample size. Note that while a larger school sample helps to maintain sample size in the face of non-response, it does not compensate for non-response bias.

### Field Test Sample

Although the PIRLS field test usually is scheduled in the school year before the year of data collection, the school sample for the PIRLS field test is drawn at the same time and from the same population of schools as the full sample. The field test sample size requirement is 200 student responses per item. For the PIRLS 2021 field test, the paper administration consisted of six booklets, with each passage and items appearing in one booklet, and so required a field test sample of 1,200 students. In addition to computer-based versions of the six paper booklets, the digitalPIRLS administration included two ePIRLS tasks arranged in two booklets (or task combinations), which required a further 200 students. Thus, the total field test sample for the digitalPIRLS administration required 1,400 students.

### Participation Rates

To minimize the potential for non-response bias, PIRLS aims for 100 percent participation of sampled schools, classrooms, and students, while recognizing that some degree of non-participation may be unavoidable. For a national sample to be fully acceptable it must have either:

- A minimum school participation rate of 85 percent, based on originally sampled schools AND
  - A minimum classroom participation rate of 95 percent, from originally sampled schools and replacement schools AND
  - A minimum student participation rate of 85 percent, from sampled schools and replacement schools
- OR
- A minimum combined school, classroom, and student participation rate of 75 percent, based on originally sampled schools (although classroom and student participation rates may include replacement schools)

Classrooms with less than 40 percent student participation are deemed to be not participating. This criterion is applied in rare circumstances. The previous cutoff of 50 percent was lowered to 40 percent in PIRLS 2021 to accommodate challenges specific to the COVID-19 pandemic. Some jurisdictions instituted hybrid models of school and remote learning, whereby on any given day only about half of eligible students were present in school for the PIRLS administration. A 40 percent student participation rate in these conditions amounts to an 80 percent student participation rate among available students.

## Developing and Implementing the National Sampling Plan

Although National Research Coordinators are responsible for developing and implementing national sampling plans, Statistics Canada and IEA Hamburg work closely with NRCs to help ensure that these sampling plans fully meet the standards set by the TIMSS & PIRLS International Study Center, while also adapting to national circumstances and requirements. National sampling plans must be based on the international two-stage sample design (schools as the first stage and classes within schools as the second stage) and must be approved by Statistics Canada.

### PIRLS Stratified Two-Stage Cluster Sample Design

The basic international sample design for PIRLS is a stratified two-stage cluster sample design, as follows:

**First Sampling Stage.** For the first sampling stage, schools are sampled with probabilities proportional to their size (PPS) from the list of all schools in the population that contain eligible students. The schools in this list (or sampling frame) may be stratified (sorted) according to important demographic variables. Schools for the field test and data collection are sampled simultaneously using a systematic random sampling approach. When possible, two replacement schools are also pre-assigned to each sampled school during the sample selection process, and these replacement schools are held in reserve should the originally sampled school refuse to participate. Replacement schools are used solely to compensate for sample size losses in the event that originally sampled schools do not participate. School sampling is conducted for each country by Statistics Canada with assistance from IEA Hamburg, using the sampling frame provided by the country's National Research Coordinator.

**Second Sampling Stage.** The second sampling stage consists of the selection of one (or more) intact class from the target grade of each participating school. Class sampling in each country is conducted by the National Research Coordinator using the Within-School Sampling Software (WinW3S) developed by IEA Hamburg and Statistics Canada. Having secured a sampled school's agreement to participate in the assessment, the National Research Coordinator requests information about the number of classes and teachers in the school and enters it in the WinW3S database. Classes smaller than a specified minimum size are grouped into pseudo-classes prior

to sampling. The software selects classes with equal probabilities within schools. All students in each sampled class participate in the assessment. Sampled classes that refuse to participate may not be replaced.

An additional sampling step is required for digitalPIRLS countries that require a bridge sample. Students in the bridge sample are administered a paper version of the trend item blocks, and it is important that this sample mirror the main digitalPIRLS sample design as closely as possible. For operational reasons it is not possible to administer both the digitalPIRLS assessment and bridge assessment in the same class, so the bridge sample consists of an extra class from a school sampled for digitalPIRLS, or from an additional school. In schools selected for both the digitalPIRLS and the bridge samples, separate classes are sampled and randomly assigned to either the digitalPIRLS or bridge samples using the WinW3S software.

## Stratification

Stratification consists of arranging the schools in the target population into groups, or strata, that share common characteristics, such as geographic region or school type. Examples of stratification variables used in PIRLS include region of the country (e.g., states or provinces); school type or source of funding (e.g., public or private); language of instruction; level of urbanization (e.g., urban or rural); socioeconomic indicators; and school performance on national examinations.

In PIRLS, stratification is used to:

- Improve the efficiency of the sample design, thereby making survey estimates more reliable
- Apply different sample designs, such as disproportionate sample allocations, to specific groups of schools (e.g., those in certain states or provinces)
- Ensure proportional representation of specific groups of schools in the sample

School stratification can take two forms: explicit and implicit. In explicit stratification, a separate school list, or sampling frame, is constructed for each stratum and a sample of schools is drawn from that stratum. In PIRLS, the major reason for considering explicit stratification is disproportionate allocation of the school sample across strata. For example, in order to produce equally reliable estimates for geographic regions in a country, explicit stratification by region may be used to ensure the same sample size for each region, regardless of the relative population size of the regions.

Implicit stratification consists of sorting the schools by one or more stratification variables within each explicit stratum, or within the entire sampling frame if explicit stratification is not used. The combined use of implicit strata and systematic sampling is a simple and effective way of ensuring a proportional sample allocation of students across all implicit strata. Implicit stratification also can lead to improved reliability of achievement estimates when the implicit stratification variables are correlated with student achievement.

National Research Coordinators consult with Statistics Canada and IEA Hamburg to identify the stratification variables to be included in their sampling plans. The school sampling frame is sorted by the stratification variables prior to sampling schools so that adjacent schools are as similar as possible. Regardless of any other explicit or implicit variables that may be used, the school size is always included as an implicit stratification variable.

To document the stratification variables used in their sampling plans, NRCs complete Sampling Form 3, which lists the variables to be used for explicit and implicit stratification, and the number of levels of each stratification variable. An example of a completed Sampling Form 3 is presented in Exhibit 3.3. Further details on the explicit and implicit stratification variables for each country can be found in the Characteristics of National Samples section in [Chapter 8: Sampling Implementation](#)

**Exhibit 3.3: Example of Sampling Form 3**

Sampling Form 3	Stratification		
<i>See Section 4 of PIRLS 2021 Survey Operations Procedures Unit 1</i>			
<b>PIRLS 2021 Participant :</b>	Country X		
1. This Sampling Form refers to:	digitalPIRLS (with ePIRLS)		
<b>Stratification of schools</b>			
2. List and describe the variables to be used for stratification in order of importance: <i>(Please note that the choice of variables used for explicit or implicit stratification will be discussed during consultations with the PIRLS sampling experts)</i>			
Stratification Variables			
	Name	Description	# of levels
1	<i>School type</i>	<i>Public, private</i>	2
2	<i>socio-economic status</i>	<i>High, medium, low</i>	3
3			
4			
5			
6			
<b>Include additional information if necessary:</b>			
3. If applicable, describe any additional requirements for sub-national estimates, either for reporting or analysis purposes (e.g., oversampling of specific groups of the population):			
<i>We would like to have reliable estimates for private schools</i>			

## School Sampling Frame

One of the National Research Coordinator's most important sampling tasks is the construction of a school sampling frame for the target population. The sampling frame is a list of all schools in the country that have students enrolled in the target grade, and is the list from which the school sample is drawn. A well-constructed sampling frame provides complete coverage of the national target population without being contaminated by incorrect or duplicate entries or entries that refer to elements that are not part of the defined target population.

A suitable school measure of size (MOS) is a critical aspect of the national sampling plan, because the size of a school determines its probability of selection. The most appropriate school measure of size is an up-to-date count of the number of students in the target grade. If the number of students in the target grade is not available, total student enrollment in the school may be a suitable substitute.

Sampling Form 4, presented in Exhibit 3.4, provides basic information about the school sampling frame, including the average class size at the target grade, the number of classrooms to be sampled per school, the school measure of size (MOS) to be used for school sampling, and the school year from which the frame was constructed.

**Exhibit 3.4: Example of Sampling Form 4**

Sampling Form 4		Classroom Information and Sampling Frame	
<i>See Section 5 of PIRLS 2021 Survey Operations Procedures Unit 1</i>			
<b>PIRLS 2021 Participant :</b>	Country X		
1. This Sampling Form refers to:	digitalPIRLS (with ePIRLS)		
2. Specify the school measure of size (MOS) to be used.			
<i>Click in box and on right arrow to see drop down menu</i>		<b>Name of the MOS variable in the school frame:</b>	
1. Number of students in the target grade (preferred)		GR4_STD	
If "Other," please describe:			
3. Specify the average class size (ACS) for the target grade in your schools.	23		
4. Specify how many classrooms you plan to sample per school. <i>(Click in box and on right arrow to see drop down menu)</i>			
3. Two classrooms in large schools			
If "Other," please describe:			
5. Specify the school year for which enrollment data will be used for the school MOS.	2019-2020		
6. If a frame other than a single-level sampling frame (list of all schools) is to be used, please provide a preliminary description of the information available to construct this frame.			
n.a.			

The school sampling frame is typically a spreadsheet containing a single entry for each school. This entry includes a unique identification number and contact information (if appropriate given the country’s privacy laws), the values of the stratification variables for the school, and the school measure of size. It is useful if the school entry also includes the number of classes in the target grade for each school because this provides a mechanism for predicting the size of the eventual student sample. This predicted sample size may be compared with the eventual student sample size as a validity check on the sampling implementation. If the number of classes is not available, one is derived based on the school’s MOS and the average class size.

Exhibit 3.5 provides an example of a partial sampling frame. In this example, socioeconomic status and school type are used as stratification variables.

**Exhibit 3.5: Example of a Partial Sampling Frame**

	A	B	C	D	E	F	G	H	I	J
1	School ID	SES	Type	Grade 4 Students	Grade 4 Classes	Excluded	School Name	School Address	City	Postal Code
2	E184510	High	Private	177	7	0	Campbell primary School	Rose Ave 86	Red River	104854
3	E136224	Medium	Public	121	5	0	Stromboli Primary School	Abbot's Drive 31	Rosetown	114766
4	E140571	Low	Public	82	3	0	Wooster Elementary School	Woodland Crescent 22	Bloombury	105532
5	E171470	Medium	Public	137	5	0	Alison Primary School	Walter Avenue 99	New Bear City	101425
6	D156972	Medium	Public	234	9	0	Middletown School	Strong Avenue 67	Carrytown	112546
7	E148426	Medium	Public	65	3	0	St John's Primary School	40th Street 13	St John	116044
8	E172294	High	Public	189	8	0	St Mary's Primary School	55th Street 12	Cambelltown	116149
9	X170050	High	Public	150	6	0	Honeydale Primary School	Clarence Road 33	Carlingtown	103153
10	X114207	High	Private	37	1	1	Green Grove Deaf School	Martin Drive 24	Lancaster	107577
11	E199157	High	Private	45	2	0	Stoneborough Primary School	Clare Crescent 7	Blue Lake	103323
12	E171645	High	Public	186	7	0	Pine Tree Primary School	5th Avenue 1	Wallington	118431
13	E128280	Low	Public	32	1	0	Pennington Elementary School	Taylor Ave 25	Wallington	108918
14	X111518	Low	Public	60	2	0	Western Community School	Katryn Road 1	Heaventown	103204
15	X129037	Medium	Private	135	5	0	Central Lane Primary School	Central lane Drive 28	Garden Heights	111495
16	D138959	Low	Public	175	7	0	Tinsdale Elementary School	Kelly Street 18	Holster	106231
17	D155958	High	Public	54	2	0	Douglas Primary School	Alice Street 10	Grahamtown	110874
18	D121060	Low	Private	103	4	0	Dry Creek Primary School	Walnut Drive 25	Grahamtown	106176
19	D143140	Medium	Private	67	3	1	Mad River Specialized School	Maple Crescent 75	Rosendale	118917
20	D152771	Medium	Private	86	3	0	Red Rose Private School	Starlight Avenue 14	Carp	105052
21	D122540	Low	Public	25	1	0	Waterloo Community School	Parkdale Ave 14	Kanata	101670
22	D164184	High	Private	15	1	0	Fruit Tree Primary School	Carling Drive 96	Brookside	118428
23	B141000			132	5	0	Tinsdale Elementary School		Brookside	107306
24					3	0	Blueberry Primary School			113976
						0	Darlington School			108556

### Sampling Schools

Once the school sampling frame is structured to meet all international and national requirements, Statistics Canada can draw the school sample. If the sampling frame is explicitly stratified, it is necessary to decide how the school sample is to be allocated among the explicit strata (i.e., the number of schools to be sampled in each stratum). When this has been decided, a sample of schools is selected within each explicit stratum using systematic sampling with probabilities proportional to size (PPS). The PPS technique means that the larger schools, those with more

students, have a higher probability of being sampled than the smaller schools. However, this difference in the selection probabilities of larger and smaller schools is largely offset at the second stage of sampling by selecting a fixed number of classes (usually one or two) with equal probability from the sampled schools. Classes in large schools with many classes at the target grade have a lower probability of selection than classes in smaller schools that have just one or two classes. A description of the school sampling procedure is provided in Appendix 3A.

Even though the field test is scheduled in the school year before the year of data collection in most countries, the preferred approach in PIRLS is to select both school samples simultaneously. This ensures that both the field test and data collection samples constitute random samples representative of all schools in the country, and that no school is selected for both samples.<sup>2</sup>

**Replacement Schools.** Ideally, all schools sampled for PIRLS should participate in the assessment, and National Research Coordinators work hard to achieve this goal. Nevertheless, it is anticipated that a 100 percent participation rate may not be possible in all countries. To avoid sample size losses, the sampling plan identifies, a priori, specific replacement schools for each sampled school. Each originally sampled school has two pre-assigned replacement schools, usually the school immediately preceding it on the school sampling frame and the one immediately following it. Replacement schools always belong to the same explicit stratum as the original, but may come from different implicit strata if the school they are replacing is either the first or last school of an implicit stratum.

The main justification for replacement schools in PIRLS is to ensure adequate sample sizes for analysis of subpopulation differences. Although the use of replacement schools does not eliminate the risk of bias due to school nonparticipation, employing implicit stratification and ordering the school sampling frame by school size increases the chances that a sampled school's replacements would have similar characteristics. This approach maintains the desired sample size while restricting replacement schools to strata where nonresponse occurs. Since the school frame is ordered by school size, replacement schools also tend to be similar in size to the school they are designated to replace.

NRCs understand that they should make every effort to secure the participation of all sampled schools. Only after all attempts to persuade a sampled school to participate have failed is the use of its replacement schools considered.

## Overlap Control in the PIRLS School Sampling Design

The PIRLS school sample design offers considerable flexibility in allowing countries to control the overlap with other national or international assessments. In some cases, countries try to ensure that assessments are spread across schools and therefore prefer that PIRLS sampling avoid,

<sup>2</sup> With approval from the TIMSS & PIRLS international Study Center, the field test sample and full sample can be selected separately. In such cases an overlap control procedure is used to minimize the probability of selecting schools for the data collection that already were sampled for the field test.

when possible, selecting schools that have recently administered other national and international assessments. To provide flexibility to meet these requests, Statistics Canada implements modified sampling procedures—the details of which are described in Appendix 3B.

## Sampling Classes

Within each sampled school, all classes with students at the target grade are listed, and one or more intact classes are selected with equal probability of selection using systematic random sampling. This procedure is implemented using the WinW3S sampling software. The selection of classes with equal probability, combined with the PPS sampling method for schools, results in a roughly self-weighting student sample. If the school has multi-grade classes (i.e., the class contains students from more than one grade level), only students from the target grade are eligible for the PIRLS assessment.

When a country participating in digitalPIRLS has schools selected for both the digitalPIRLS and the bridging assessments, sampled classes within these schools are randomly assigned to one study or the other. This is done automatically within the WinW3S software.

Because small classes tend to increase the risk of less reliable survey estimates from weight fluctuations and can lead to reduced overall student sample size, it is necessary to minimize sampling small classes. Prior to sampling classes in a school, any class smaller than half the average class size is combined with another class in the school to form a “pseudo-class” for sampling purposes. The procedure for sampling classes within schools is described in more detail in [Chapter 4](#).

## Sampling Weights

National student samples in PIRLS are designed to accurately represent the target population within a specified margin of sampling error, as described earlier. After the data have been collected and processed, sample statistics such as means and percentages that describe student characteristics are computed as weighted estimates of the corresponding population parameters, where the weighting factor is the sampling weight. A student’s sampling weight is essentially the inverse of the student’s probability of selection, with appropriate adjustments for nonresponse. In principle, the stratified two-stage sampling procedure used in PIRLS, where schools are sampled with probability proportional to school size and classes are sampled with equal probability within schools, provides student samples with roughly equal selection probabilities. In practice, disproportionate sampling across explicit strata, variations in the number of classes selected, and differential patterns of nonresponse can result in varying selection probabilities, requiring a unique sampling weight for the students in the PIRLS samples.

The student sampling weight in PIRLS is a combination of weighting components reflecting selection probabilities and sampling outcomes at three levels—school, class, and student. At each

level, the weighting component consists of a basic weight that is the inverse of the probability of selection at that level, together with an adjustment for nonparticipation. The overall sampling weight for each student is the product of the three weighting components: school, class (within school), and student (within class).

The bridge samples of digitalPIRLS countries also have sampling weights derived in a manner analogous to the description above. Further details on the special weight adjustments for digitalPIRLS and the bridge data may be found in [Chapter 8: Sampling Implementation](#)

### School Weighting Component

Given that schools in PIRLS are sampled with probability proportional to school size, the basic school weight for the  $i^{\text{th}}$  sampled school (i.e., the inverse of the probability of the  $i^{\text{th}}$  school being sampled) is defined as:

$$BW_{sc}^i = \frac{M}{n \cdot m_i} \quad (3.1)$$

where  $n$  is the number of sampled schools,  $m_i$  is the measure of size for the  $i^{\text{th}}$  school, and

$$M = \sum_{i=1}^N m_i \quad (3.2)$$

where  $N$  is the total number of schools in the explicit stratum.<sup>3,4</sup>

**School Nonparticipation Adjustment.** If a sampled school does not participate in PIRLS and its two designated replacement schools do not participate, it is necessary to adjust the basic school weight to compensate for the reduction in sample size. The school-level nonparticipation adjustment is calculated separately for each explicit stratum, as follows:

$$A_{sc} = \frac{n_s + n_{r1} + n_{r2} + n_{nr}}{n_s + n_{r1} + n_{r2}} \quad (3.3)$$

where  $n_s$  is the number of originally sampled schools that participated,  $n_{r1}$  and  $n_{r2}$  the number of first and second replacement schools, respectively, that participated, and  $n_{nr}$  is the number of schools that did not participate. Sampled schools that are found to be ineligible<sup>5</sup> are not included in the calculation of this adjustment.

3 For countries such as the Russian Federation that include a preliminary sampling stage, the basic school weight also incorporates the probability of selection in this preliminary stage. The basic school weight in such cases is the product of the preliminary stage weight and the school weight.

4 In schools selected for both the digitalPIRLS and the bridge samples, sampled classes are randomly assigned to either the digitalPIRLS or the bridge samples using the WinW3S software. If such a school has only one class, WinW3S randomly assigns the class to one of the samples (digitalPIRLS or bridge). In such cases, an adjustment is applied to the school weight in the corresponding explicit stratum of the non-selected sample.

5 A sampled school is ineligible if it is found to contain no eligible students (i.e., no students in the target grade). Such schools usually are in the sampling frame by mistake or are schools that recently have closed.

Combining the basic school weight and the school nonparticipation adjustment, the final school weighting component for the  $i^{\text{th}}$  school becomes:

$$FW_{sc}^i = A_{sc} \cdot BW_{sc}^i \quad (3.4)$$

It should be noted that, as well as being a crucial component of the overall student weight, the final school weighting component is a sampling weight in its own right, and can be used in analyses where the school is the unit of analysis.

### Class Weighting Component

The class weighting component reflects the class-within-school selection probability. After a school has been sampled and has agreed to participate in PIRLS, one or two classes are sampled with equal probability from the list of all classes in the school at the target grade. Because larger schools have more classes from which to sample than smaller schools, the probability of class selection varies with school size, with students in small schools more likely to have their class selected than students in large schools. This relatively greater selection probability for students in small schools offsets their lower selection probability at the first stage, where probability-proportional-to-size school sampling results in higher selection probabilities for larger schools.

The basic class-within-school weight for a sampled class is the inverse of the probability of the class being selected from all of the classes in its school. For the  $i^{\text{th}}$  sampled school, let  $C^i$  be the total number of eligible classes and  $c^i$  the number of sampled classes. Using equal probability sampling, the basic class weight for all sampled classes in the  $i^{\text{th}}$  school is:

$$BW_{cl}^i = \frac{C^i}{c^i} \quad (3.5)$$

For most PIRLS participants,  $c^i$  takes the values 1 or 2. In rare instances,  $c^i = C^i$ .

**Class Nonparticipation Adjustment.** A class-level nonparticipation adjustment is applied to compensate for classes that do not participate or where the student participation rate is below 40 percent. Such sampled classes are assigned a weight of zero. Class nonparticipation adjustments are applied at the explicit stratum level rather than at the school level to minimize the risk of bias. Thus, the class nonparticipation adjustment is the same for all schools in a given explicit stratum. The adjustment is calculated as follows:

$$A_{cl} = \frac{\sum_i^{s+r1+r2} 1}{\sum_i^{s+r1+r2} \delta_i / c^i} \quad (3.6)$$

where  $c^i$  is the number of sampled classes in the  $i^{\text{th}}$  school, as defined earlier, and  $\delta_i$  gives the number of participating classes in the  $i^{\text{th}}$  school.

Combining the basic class weight and the class nonparticipation adjustment, the final class weighting component, assigned to all sampled classes in the  $i^{\text{th}}$  school, becomes:

$$FW_{cl}^{i,j} = A_{cl} \cdot BW_{cl}^i \quad (3.7)$$

## Student Weighting Component

The student weighting component represents the student-within-class selection probability. The basic student weight is the inverse of the probability of a student in a sampled class being selected.

In the typical PIRLS situation where intact classes are sampled, all students in the class are included, and so this probability is unity. However, under certain circumstances, students may be sampled within the class, and in these circumstances the probability is less than unity.

For an intact class with no student subsampling, the basic student weight for the  $j^{\text{th}}$  class in the  $i^{\text{th}}$  school is computed as follows:

$$BW_{st1}^{i,j} = 1.0 \quad (3.8)$$

For classes with student subsampling, the basic student weight for the  $j^{\text{th}}$  class in the  $i^{\text{th}}$  school is:

$$BW_{st2}^{i,j} = \frac{n_{rg}^{i,j} + n_{bs}^{i,j}}{n_{rg}^{i,j}} \quad (3.9)$$

where  $n_{rg}^{i,j}$  is the number of students in the  $j^{\text{th}}$  class of the  $i^{\text{th}}$  school selected to participate in PIRLS and  $n_{bs}^{i,j}$  is the number of students in the class not selected.

**Student Non-Participation Adjustment.** The student nonparticipation adjustment for the  $j^{\text{th}}$  classroom in the  $i^{\text{th}}$  school is calculated as:

$$A_{st1}^{i,j} = A_{st2}^{i,j} = A_{st3}^{i,j} = \frac{s_{rs}^{i,j} + s_{nr}^{i,j}}{s_{rs}^{i,j}} \quad (3.10)$$

where  $s_{rs}^{i,j}$  is the number of participating students in the  $j^{\text{th}}$  class of the  $i^{\text{th}}$  school and  $s_{nr}^{i,j}$  is the number of students sampled in this class who were selected but did not participate in the assessment. For intact classes, the sum of  $s_{rs}^{i,j}$  and  $s_{nr}^{i,j}$  is the total number of students listed in the class, not counting excluded students or students who have left the school since the class list was published.

The final student weighting component for students in the  $j^{\text{th}}$  classroom of the  $i^{\text{th}}$  school is:

$$FW_{st}^{i,j} = A_{st\Delta}^{i,j} \cdot BW_{st\Delta}^{i,j} \quad (3.11)$$

where  $\Delta$  equals 1 when there is no student subsampling (intact classes), and 2 when a sample of students is drawn from the students in the class.

### Overall Student Sampling Weight

The overall student sampling weight is the product of the final weighting components for schools, classes, and students, as follows:

$$W^{i,j} = FW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j} \quad (3.12)$$

Overall student sampling weights are attributed only to participating students, with non-participating students weighted at 0. All student data reported in the PIRLS international reports are weighted by the overall student sampling weight, known as TOTWGT in the PIRLS international databases.

## Participation Rates

Because nonparticipation can result in sample bias and misleading results, it is important that the schools, classes, and students that are sampled in PIRLS actually take part in the assessment. To show the level of sampling participation in each country, PIRLS calculates both unweighted participation rates (i.e., based on simple counts of schools, classes, and students) and weighted participation rates based on the sampling weights described in the previous section. Unweighted participation rates provide a preliminary indicator that may be used to monitor progress in securing the participation of schools and classes, whereas weighted participation rates are the ultimate measures of sampling participation.

PIRLS reports weighted participation rates as well as unweighted participation rates for schools, classes, and students, and overall participation rates that are a combination of all three. To distinguish between participation based solely on originally sampled schools and participation that also relies on replacement schools, school and overall participation rates are computed separately for originally sampled schools only and for originally sampled schools together with replacement schools.

### Unweighted School Participation Rate

The unweighted school participation rate is the ratio of the number of participating schools to the number of originally sampled schools, excluding any sampled schools found to be ineligible. A school is considered to be a “participating school” if at least one of its sampled classes has a

student participation rate of at least 40 percent. The two unweighted school participation rates are calculated as follows:

$R_{unw}^{sc-s}$  = unweighted school participation rate for originally sampled schools only

$R_{unw}^{sc-r}$  = unweighted school participation rate, including sampled and first and second replacement schools

$$R_{unw}^{sc-s} = \frac{n_s}{n_s + n_{r1} + n_{r2} + n_{nr}} \quad (3.13)$$

$$R_{unw}^{sc-r} = \frac{n_s + n_{r1} + n_{r2}}{n_s + n_{r1} + n_{r2} + n_{nr}} \quad (3.14)$$

### Unweighted Class Participation Rate

The unweighted class participation rate is the ratio of the number of sampled classes that participated to the number of classes sampled, as follows:

$$R_{unw}^{cl} = \frac{\sum_i^{s+r1+r2} c^i}{\sum_i c^i} \quad (3.15)$$

where  $c^i$  is the number of sampled classes in the  $i^{\text{th}}$  school, and  $c_*^i$  is the number of participating classes in the  $i^{\text{th}}$  school. Both summations are across all participating schools.

### Unweighted Student Participation Rate

The unweighted student participation rate is the ratio of the number of selected students that participated in PIRLS to the total number of selected students that should have been assessed in the participating schools and classes. Classes where less than 40 percent of the students participated are considered to be not participating, and so students in such classes also are considered to be nonparticipants. The unweighted student participation rate is computed as follows:

$$R_{unw}^{st} = \frac{\sum_{i,j} s_{rs}^{i,j}}{\sum_{i,j} s_{rs}^{i,j} + \sum_{i,j} s_{nr}^{i,j}} \quad (3.16)$$

## Overall Unweighted Participation Rate

The overall unweighted participation rate is the product of the unweighted school, class, and student participation rates. Because PIRLS computes two versions of the unweighted school participation rate, one based on originally sampled schools only and the other including replacements as well as originally sampled schools, there also are two overall unweighted participation rates:

$R_{unw}^{ov-s}$  = unweighted overall participation rate for originally sampled schools only

$R_{unw}^{ov-r}$  = unweighted overall participation rate, including sampled and first and second replacement schools

$$R_{unw}^{ov-s} = R_{unw}^{sc-s} \cdot R_{unw}^{cl} \cdot R_{unw}^{st} \quad (3.17)$$

$$R_{unw}^{ov-r} = R_{unw}^{sc-r} \cdot R_{unw}^{cl} \cdot R_{unw}^{st} \quad (3.18)$$

## Weighted School Participation Rate

The weighted school participation rate is the ratio of two estimates of the size of the target student population. The numerator is derived from the measure of size of those sampled schools that participated in PIRLS and the denominator is the weighted estimate of the total student enrollment in the population. Weighted school participation rates are computed for originally sampled schools and for originally sampled and replacement schools combined, as follows:

$R_{wtd}^{sc-s}$  = weighted school participation rate for originally sampled schools only

$R_{wtd}^{sc-r}$  = weighted school participation rate, including sampled and first and second replacement schools

$$R_{wtd}^{sc-s} = \frac{\sum_{i,j} BW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}}{\sum_{i,j} FW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}} \quad (3.19)$$

$$R_{wtd}^{sc-r} = \frac{\sum_{i,j}^{s+r1+r2} BW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}}{\sum_{i,j}^{s+r1+r2} FW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}} \quad (3.20)$$

Summations in both the numerator and denominator are over all responding students and include appropriate class and student sampling weights. Note that the basic school weight appears in the numerator, whereas the final school weight appears in the denominator.

### Weighted Class Participation Rate

The weighted class participation rate is computed as follows:

$$R_{wtd}^{cl} = \frac{\sum_{i,j}^{s+r1+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot FW_{st}^{i,j}}{\sum_{i,j}^{s+r1+r2} BW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}} \quad (3.21)$$

where both the numerator and denominator are summations over all responding students from classes with at least 40 percent of their students participating in the study, and the appropriate student-level sampling weights are used. In this formula, the basic class weight appears in the numerator, whereas the final class weight appears in the denominator. And, the denominator in this formula is the same quantity that appears in the numerator of the weighted school participation rate for all schools, whether originally sampled or replacement.

### Weighted Student Participation Rate

The weighted student participation rate is computed as follows:

$$R_{wtd}^{st} = \frac{\sum_{i,j}^{s+r1+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot BW_{st}^{i,j}}{\sum_{i,j}^{s+r1+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot FW_{st}^{i,j}} \quad (3.22)$$

where both the numerator and denominator are summations over all responding students from participating schools. In this formula, the basic student weight appears in the numerator, whereas the final student weight appears in the denominator. Also, the denominator in this formula is the same quantity that appears in the numerator of the weighted class participation rate for all participating schools, whether originally sampled or replacement.

### Overall Weighted Participation Rate

The overall weighted participation rate is the product of the weighted school, class, and student participation rates. Because there are two versions of the weighted school participation rate, one based on originally sampled schools only and the other including replacement as well as originally sampled schools, there also are two overall weighted participation rates:

$R_{wtd}^{ov-s}$  = weighted overall participation rate for originally sampled schools only

$R_{wtd}^{ov-r}$  = weighted overall participation rate, including sampled, first and second replacement schools

$$R_{wtd}^{ov-s} = R_{wtd}^{sc-s} \cdot R_{wtd}^{cl} \cdot R_{wtd}^{st} \quad (3.23)$$

$$R_{wtd}^{ov-r} = R_{wtd}^{sc-r} \cdot R_{wtd}^{cl} \cdot R_{wtd}^{st} \quad (3.24)$$

Weighted school, class, student, and overall participation rates are computed for each PIRLS participating country using these procedures.

## References

- Chowdhury, S., Chu, A., & Kaufman, S. (2000). Minimizing overlap in NCES surveys. In JSM Proceedings, Survey Research Methods Section. Alexandria, VA: American Statistical Association. 147-179. Retrieved from [http://www.asasrms.org/Proceedings/papers/2000\\_025.pdf](http://www.asasrms.org/Proceedings/papers/2000_025.pdf)
- UNESCO. (2012). *International Standard Classification of Education (ISCED) 2011*. Montreal, Quebec: UNESCO Institute of Statistics. Retrieved from <http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf>

## Appendix 3A: Sampling Schools

PIRLS employs random-start, fixed-interval, systematic sampling to draw the school samples, with each school selected with probability proportional to its size (PPS).

To sample schools using the PPS systematic sampling method, the schools from each explicit stratum in the sampling frame are sorted by implicit stratification variables and by their measure of size (MOS), as shown in the example in Exhibit 3.6. The MOS is accumulated from school to school and the running total (the Cumulative MOS) is listed next to each school. The cumulative MOS across the entire stratum (the Total MOS) is a measure of the size of the school population in the stratum (59,614 students in the example).

### First Step: Compute the Sampling Interval

Dividing the Total MOS by the number of schools required for the sample (50 in the example) gives the sampling interval.

- $59,614 \div 50 = 1,192.2800$

### Second Step: Generate a Random Start

Generate a random number from a uniform (0,1) distribution and multiply it by the sampling interval. The school whose cumulative MOS contains the resulting number is the first school in the sample.

- $0.5481 \times 1,192.2800 = 653.4887$
- **School 1718**, with cumulative **MOS** of **690**, is the first school in the sample.

### Third Step: Identify the Next School in the Sample (repeat until all schools are sampled)

- Add the sampling interval to the number computed in the previous step:  
 $653.4887 + 1,192.2800 = 1,845.7687$   
**School 0067**, with cumulative **MOS** of **1,855**, is the second school in the sample.
- Repeat until all schools are sampled. For the example, to identify the third school:  
 $1,845.7687 + 1,192.2800 = 3,038.0487$   
**School 0333**, with cumulative **MOS** of **3,038**, is the third school in the sample.

### Fourth Step: Identify Replacement Schools

Two replacement schools are identified for each sampled school. The first replacement (R1) is the school that immediately follows the sampled school in the sampling frame, and the second replacement (R2) the school that immediately precedes the sampled school.

**Exhibit 3.6: Example of PPS Systematic Sampling—Schools**

Sampling Parameters		School Identifier	School MOS	Cumulative MOS	Sampled Schools
Total Number of Schools:	2,119	0829	110	110	
Total Measure of Size:	59,614	0552	101	211	
School Sample Size:	50	1802	98	309	
Sampling Interval:	1,192.2800	1288	98	407	
Random Start:	653.4887	2043	95	502	
		0974	94	596	R2
		1718	94	690	✓
		1807	93	783	R1
		0457	93	876	
		0244	93	969	
		1817	91	1,060	
		1741	90	1,150	
		1652	89	1,239	
		0121	89	1,328	
		0309	89	1,417	
		0032	89	1,506	
		0021	89	1,595	
		0609	88	1,683	
		0399	86	1,769	R2
		0067	86	1,855	✓
		0202	86	1,941	R1
		0063	86	2,027	
		1467	86	2,113	
		1381	86	2,199	
		1043	84	2,283	
		1318	84	2,367	
		0659	84	2,451	
		0612	83	2,534	
		1696	82	2,616	
		0867	82	2,698	
		0537	81	2,779	
		1794	80	2,859	
		0695	80	2,939	
		0031	80	3,019	R2
		0333	79	3,098	✓
		0051	79	3,177	R1
		0384	79	3,256	
		1361	79	3,335	
		1189	79	3,414	
		0731	78	3,492	
		0634	78	3,570	
		1230	77	3,647	

**First Step**

**Compute the Sampling Interval:**  
 $59,6914 \div 50 = 1,192.2800$

**Second Step**

**Generate a random start:**  
 $0.5481 \times 1,192.2800 = 653.4887$

**Third Step (repeat until complete)**

**Compute the next selection numbers:**  
 $653.4887 + 1,192.2800 = 1,845.7687$   
 $1,845.7687 + 1,192.2800 = 3,038.0487$

**Fourth Step**

**Identify Replacement Schools (R1, R2)**

## Appendix 3B: School Sampling Design Options to Accommodate Other Samples

PIRLS provides an optional modification to its sampling design for countries that want to control overlap between schools sampled for PIRLS and schools sampled for other national or international assessments.

The special sampling procedure implemented by Statistics Canada uses a technique described in Chowdhury, Chu, and Kaufman (2000). As explained by the authors, the method can be used to either minimize or maximize overlap amongst several samples. This method is illustrated below with an example where the aim is to minimize the overlap between a current school sample  $S_2$  and a previously selected school sample  $S_1$ . (For a complete description of the method, readers are referred to the original paper).

Let RL (Response Load) be the number of times a school was sampled from previous samples. In this example, given that there is only one previous sample, RL takes the value 1 if the school was already selected and 0 otherwise.

Given that the RL variable splits the current school frame in two distinct subsets of schools,  $S_1$  where  $RL=1$  and  $\bar{S}_1$  where  $RL=0$ , we have the following relation:

$$P_i(S_2) = P_i(S_2|S_1) \cdot P_i(S_1) + P_i(S_2|\bar{S}_1) \cdot P_i(\bar{S}_1) \quad (3.25)$$

where  $P_i(S_j)$  gives the probability that school  $i$  be selected in the sample  $S_j$ , and  $P_i(S_j|S_k)$  gives the probability that school  $i$  be selected in sample  $S_j$  given that school  $i$  already belongs to  $S_k$ . The idea is to derive the conditional probabilities in such a way that the unconditional probability of selecting a school in the current sample,  $P_i(S_2)$ , be equal to the expected probability (as defined by the PIRLS sample design).

Note that the first term after the equal sign in equation (3.25) is related to cases where the school response load is 1, while the last term is related to cases where the school response load is 0. Therefore, minimizing the sample overlap is equivalent to zeroing the first term. In such case, equation (3.25) becomes:

$$P_i(S_2) = 0 \cdot P_i(S_1) + P_i(S_2|\bar{S}_1) \cdot P_i(\bar{S}_1) \quad (3.26)$$

and consequently,

$$P_i(S_2|\bar{S}_1) = P_i(S_2)/P_i(\bar{S}_1) \quad (3.27)$$

In other words, in the current sample  $S_2$ , schools would be selected with the following conditional probabilities:

$$\begin{cases} 0 & \text{if school } i \text{ was already selected in the first sample,} \\ P_i(S_2)/P_i(\bar{S}_1) & \text{otherwise} \end{cases} \quad (3.28)$$

However, equation (3.25) no longer holds if expression  $P_i(S_2)/P_i(\bar{S}_1)$  is greater than 1. This can be avoided by setting 1 as an upper bound. We now have the following expression:

$$P_i(S_2) = P_i(S_2|S_1) \cdot P_i(S_1) + 1 \cdot P_i(\bar{S}_1) \quad (3.29)$$

and consequently

$$\frac{P_i(S_2) - P_i(\bar{S}_1)}{P_i(S_1)} = P_i(S_2|S_1) \quad (3.30)$$

Combining these two results, the conditional probabilities to use when selecting the current sample of schools are given by:

$$\begin{cases} \text{Max} \left[ 0, \frac{P_i(S_2) - P_i(\bar{S}_1)}{P_i(S_1)} \right] & \text{if school } i \text{ was already selected in the first sample,} \\ \text{Min} \left[ \frac{P_i(S_2)}{P_i(\bar{S}_1)}, 1 \right] & \text{otherwise} \end{cases} \quad (3.31)$$

Note that maximizing rather than minimizing the overlap between two studies can be done by simply zeroing the last term of equation (3.25) rather than zeroing the first term, and following the same logic to derive the appropriate conditional probabilities. The Chowdhury et al. (2000) method can be generalized to more than two samples, as described in their paper.

Further details about the implementation of this method for the countries and benchmark participants can be found in [Chapter 8: Sampling Implementation](#).