

Sample Design in TIMSS and PIRLS

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Introduction

TIMSS and PIRLS are designed to provide valid and reliable measurement of trends in student achievement in countries around the world, while keeping to a minimum the burden on schools, teachers, and students. Both programs employ 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. TIMSS assesses mathematics and science achievement at two grade levels and so TIMSS has two target populations—all students enrolled at the fourth grade and all students enrolled at the eighth grade. Countries may assess either or both student populations. As an assessment of reading comprehension in primary school, the target population for PIRLS is all students enrolled at the fourth grade.

TIMSS and PIRLS both employ the same 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 because TIMSS and PIRLS pay 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 business than individual student sampling.

National Sampling Plan

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

Statistics Canada is responsible for advising the National Research Coordinator on all sampling matters and for ensuring that the national sampling plan conforms to the TIMSS and PIRLS standards. In cooperation

with sampling staff from the IEA Data Processing and Research Center (DPC), Statistics Canada works with the National Research Coordinator to select the national school sample(s) and produce all supporting documentation for tracking the sampled schools. This includes ensuring that the school sampling frame (the school population list from which the school sample is drawn) provided by the National Research Coordinator is complete and satisfactory; checking that categories of excluded students are clearly defined, justified, and kept to a minimum; assisting the National Research Coordinator in determining the sample size and a stratification plan that will meet both international and national objectives; and drawing a national sample of schools. When sampling has been completed and all data collected, Statistics Canada documents population coverage and 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 the IEA DPC, provides National Research Coordinators with a series of manuals to guide them through the sampling process. More specifically, *TIMSS & PIRLS Survey Operations Procedures Unit 1: Sampling Schools and Obtaining their Cooperation* (TIMSS & PIRLS International Study Center, 2008) describes the steps involved in defining the national target population and selecting the school sample, and *TIMSS & PIRLS Survey Operations Procedures Unit 3: Contacting Schools and Sampling Classes* (TIMSS & PIRLS International Study Center, 2010) describes the procedure for sampling classes within the sampled schools and making preparations for conducting the assessments. Within-school sampling procedures for the field test are documented in *TIMSS & PIRLS Survey Operations Procedures Unit 2: Preparing for and Conducting the Field Test* (TIMSS & PIRLS International Study Center, 2009).

The TIMSS or PIRLS National Research Coordinator is responsible for providing Statistics Canada with all information and documentation necessary to conduct the national sampling, and for conducting all sampling operations in the country. In particular, the NRC is expected to identify the grade(s) that correspond to the international target population(s); create a sampling frame by listing all schools in the population that have classes with students in the target grade(s); determine national population coverage and exclusions, in accordance with the TIMSS and 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. Each NRC is required to complete a series of sampling forms documenting the completion of each of these tasks.

A crucial feature of each international meeting of National Research Coordinators is a one-to-one meeting between each NRC and sampling staff at Statistics Canada and the IEA DPC. 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 or the International Sampling Referee, as necessary, to resolve issues and questions. Final approval of TIMSS and 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 international studies of the comparative effects of education on student achievement in mathematics, science, and reading, TIMSS and PIRLS define their international target populations 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 international target population for PIRLS and TIMSS at the lower grade is all students in their fourth year of formal schooling, and for TIMSS at the upper grade, all students in their eighth year of formal schooling.

UNESCO's International Standard Classification of Education (ISCED) 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 second level of tertiary education (Level 6). ISCED Level 1 corresponds to primary education or the first stage of basic education. The first year of Level 1 should mark the beginning of "systematic apprenticeship of reading, writing, and mathematics" (UNESCO, 1999). Four years after this would be the target grade for PIRLS and fourth grade TIMSS, and is the fourth grade in most countries. Similarly, eight years after the first year of ISCED Level 1 is the target grade for eighth grade TIMSS and is the eighth grade in most countries. However, given the cognitive demands of the

assessments, TIMSS and PIRLS want to avoid assessing very young students. Thus, TIMSS and PIRLS recommend assessing the next higher grade (i.e., fifth grade for PIRLS or fourth grade TIMSS and ninth grade for eighth grade TIMSS) if, for fourth grade students, the average age at the time of testing would be less than 9.5 years and, for eighth grade students, less than 13.5 years.

The fourth-grade and eighth-grade target populations of students are defined as follows:

Fourth-grade (PIRLS and TIMSS): 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.

Eighth-grade (TIMSS only): All students enrolled in the grade that represents eight years of schooling counting from the first year of ISCED Level 1, providing the mean age at the time of testing is at least 13.5 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 TIMSS and 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 TIMSS or 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 Populations

For most countries, the target grade for PIRLS or TIMSS is the fourth and/or eighth 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 grades are labelled and in the average age of students. To ensure that the appropriate national target grades are selected, each NRC completes Sampling Form 1, which identifies the target grades, the country's name for those grades, and the average age of students in those grades at the time of data collection. (To view an example of a completed Sampling Form 1 for TIMSS and PIRLS in 2011, [please click here.](#))

National Coverage and Exclusions

TIMSS and PIRLS are designed to describe and summarize student achievement across the entire target grade (fourth or eighth), and so it is very important that national target populations aim for comprehensive coverage of eligible students. However, in some cases, political, organizational, or operational factors make complete national coverage difficult to attain. Thus, in some rare 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 as reduced population coverage.

Even countries with 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; or
- ◆ Providing instruction solely to students in the student-level exclusion categories listed below (i.e., 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 and/or TIMSS testing situation. Students with functional disabilities who are able to perform should be included in the testing.
- ◆ **Students with intellectual disabilities** — These are students who are considered, in the professional opinion of the school principal or by

other qualified staff members, to have intellectual disabilities or who have been tested as such. This includes students who are emotionally or mentally unable to follow even 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 TIMSS and 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.

- ◆ The overall number of excluded students must not account for more than 5% 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% 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 within the school for each population to be assessed. (To view an example of a completed Sampling Form 2 for TIMSS and PIRLS in 2011, [please click here.](#))

Requirements for Sampling the Target Population

TIMSS & PIRLS set high standards for sampling precision, participation rates and sample implementation in order to achieve national samples of the highest quality and survey estimates that are unbiased, accurate and internationally comparable.

SAMPLING PRECISION AND SAMPLE SIZE

Because TIMSS and PIRLS are fundamentally studies of student achievement, the precision of estimates of student achievement is of primary importance. To meet the TIMSS & PIRLS standards for sampling precision, national student samples should provide for a standard error no greater than .035 standard deviation units for the country's mean achievement. With a standard deviation of 100 on the TIMSS and PIRLS achievement scales, this standard error corresponds to a 95% confidence interval of ± 7 score points for the achievement mean and of ± 10 score points for the difference between achievement means from successive cycles (e.g., the difference between a country's achievement mean on TIMSS 2007 and TIMSS 2011). Sample estimates of any student-level percentage estimate (e.g., a student background characteristic) should have a confidence intervals of $\pm 3.5\%$.

For most countries, the TIMSS and PIRLS precision requirements are met with a school sample of 150 schools and a student sample of 4,000 students for each target grade. 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 were 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 a better estimate of school-level effects.

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.
- ◆ Previous cycles of TIMSS and/or PIRLS showed that the sampling precision requirements cannot be met unless a larger school sample is selected.
- ◆ Classes within schools are tracked by student performance (more common at eighth grade than at fourth grade). This increases variation between classes in student achievement and can reduce sampling precision. 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 The school sample for the field test for TIMSS and PIRLS 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 students per field test achievement booklet. The total field test sample size is a function of the number of achievement booklets being field tested. Typically, PIRLS has four field test booklets and so requires a field test sample of 800 students, whereas TIMSS with six booklets requires a sample of 1200 students at each grade.

PARTICIPATION RATES

To minimize the potential for non-response bias, PIRLS and TIMSS aim for 100% participation by 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%, based on originally sampled schools; *AND*
- ◆ A minimum classroom participation rate of 95%, from originally sampled schools and replacement schools; *AND*
- ◆ A minimum student participation rate of 85%, from sampled schools and replacement schools;

OR

- ◆ A minimum combined school, classroom and student participation rate of 75%, based on originally sampled schools (although classroom and student participation rates may include replacement schools).

Classrooms with less than 50% student participation are deemed to be not participating.

Developing and Implementing the National Sampling Plan

Although National Research Coordinators are responsible for developing and implementing national sampling plans, Statistics Canada and the IEA DPC 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. (For more information about the TIMSS & PIRLS international sample design, [please click here.](#))

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 TIMSS and 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 area); socio-economic indicators; and school performance on national examinations.

In TIMSS and 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 TIMSS and 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 each geographic region in a country, explicit stratification by region may be used to ensure the same number of schools in the sample 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 very effective and simple way of ensuring a proportional sample allocation of students across all implicit strata. Implicit stratification also can lead to improved reliability of achievement estimates, provided the implicit stratification variables are correlated with student achievement. (To

view a summary of the stratification variables used by countries in TIMSS & PIRLS in 2011, [please click here.](#))

National Research Coordinators consult with Statistics Canada and the IEA DPC 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, each NRC completes Sampling Form 3, which lists the variables to be used for explicit and implicit stratification, and the number of levels of each stratification variable. (To view an example of a completed Sampling Form 3 for TIMSS and PIRLS in 2011, [please click here.](#))

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. If the national sampling plan calls for explicit stratification, there should be a separate sampling frame for each explicit stratum.

A suitable school measure of size (MOS) is a critical aspect of the national sampling plan, because the size of the school determines the school's 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, the total student enrolment in the school may be the best available substitute.

Sampling Form 4 provides some 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 for which the frame was constructed. (To view an example of a completed Sampling Form 4 for TIMSS and PIRLS in 2011, [please click here.](#))

The school sampling frame is usually 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 school in the target grade because this provides a mechanism for predicting in advance the size of the eventual student sample. This predicted sample size may be compared with the eventual student sample size as a check on the sampling process.

For an example of a partial sampling frame for a country assessing TIMSS 2011 at the eighth grade, [please click here](#). In this example, region and urbanization could be used as stratification variables.

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. (For a description of the school sampling procedure, [please click here](#).) 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 school. 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.

Even though the field test is scheduled in the school year before the year of data collection in most countries, the preferred approach in TIMSS and PIRLS is to select both samples of schools at the same time. 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.

Replacement Schools Although ideally all schools sampled for TIMSS and PIRLS should participate in the assessments, and although NRCs work hard to achieve this goal, 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 the originally sampled school on the school sampling frame and the one immediately following it. Replacement schools always belong to the same explicit stratum as the original, but although they 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 TIMSS and 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 of the sampled schools and that only after all attempts to persuade a sampled school to participate have failed should the use of its replacement school be considered.

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, in general results in a 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 sampling.

Because small classes tend to increase the risk of unreliable survey estimates and can lead to reduced overall student sample size, it is necessary to avoid sampling too many small classes. Based on consideration of the size distribution of classes and the average class size, a lower class size limit or minimum class size (MCS) is specified for each country. Prior to sampling classes in a school, any class smaller than the MCS is combined with another class in the school to form a “pseudoclass” for sampling purposes. The procedure for sampling classes

within schools is described in more detail in “Survey Operations and Quality Assurance.”

Sampling Weights

National student samples in TIMSS and PIRLS are designed to accurately represent the target populations within a specified margin of sampling error, as described previously. 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 TIMSS and PIRLS, where schools are sampled with probability proportional to school size and classes are sampled with probability inversely proportional to school size, provides student samples with equal selection probabilities. However, in practice disproportionate sampling across explicit strata varying 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 each participating class in the study.

The student sampling weight in TIMSS and 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).

School Weighting Component

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

$$BW_{sc}^i = \frac{M}{n \cdot m_i}$$

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

$$M = \sum_{i=1}^N m_i$$

where N is the total number of schools in the explicit stratum.¹

School Nonparticipation Adjustment — If a sampled school does not participate in TIMSS or PIRLS and neither does either of its two designated replacement schools, 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:

$$A_{sc} = \frac{n_s + n_{r1} + n_{r2} + n_{nr}}{n_s + n_{r1} + n_{r2}}$$

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 ineligible² are not included in the calculation of this adjustment.

In countries where the TIMSS or PIRLS sample is a census of all schools in the target grades (e.g., Bahrain, Cyprus, Kuwait, Malta, and Qatar), the following school-level adjustment is used:

$$A_{sc} = \frac{m_s + m_{nr}}{m_s}$$

where m_s is the sum of the measures of size (number of students) from schools that participated and m_{nr} the sum of the measures of size from schools that did not participate.

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

$$FW_{sc}^i = A_{sc} \cdot BW_{sc}^i$$

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 should be used in analyses where the school is the analytic unit.

Class Weighting Component

The class weighting component reflects the class-within-school selection

1 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.

2 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.

probability. After a school has been sampled and has agreed to participate in TIMSS or 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^{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^{th} school is:

$$BW_{cl}^i = \frac{C^i}{c^i}$$

For most TIMSS or PIRLS participants, c^i takes the values 1 or 2.

Class Nonparticipation Adjustment — Basic class weights are calculated for all sampled classes in the sampled and replacement schools that participate in TIMSS or PIRLS. A class-level nonparticipation adjustment is applied to compensate for classes that do not participate or where the student participation rate is below 50 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. The adjustment is calculated as follows:

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

where c^i is the number of sampled classes in the i^{th} school, as defined earlier, and δ gives the number of participating classes in the i^{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^{th} school, becomes:

$$FW_{cl}^{i,j} = A_{cl} \cdot BW_{cl}^i$$

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 TIMSS and 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, with probability less than unity.

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

$$BW_{st1}^{i,j} = 1.0$$

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

$$BW_{st2}^{ij} = \frac{n_{rg}^{i,j} + n_{bs}^{i,j}}{n_{rg}^{i,j}}$$

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

Adjustment for Student Nonparticipation — The student nonparticipation adjustment for the j^{th} classroom in the i^{th} school is calculated as:

$$A_{st1}^{i,j} = A_{st2}^{i,j} = \frac{s_{rs}^{i,j} + s_{nr}^{i,j}}{s_{rs}^{i,j}}$$

where $s_{rs}^{i,j}$ is the number of participating students (i.e., students that participated in TIMSS or PIRLS and have assessment scores) in the j^{th} class of the i^{th} school, and $s_{nr}^{i,j}$ is the number of students sampled in this class and expected to have assessment scores but did not participate in the assessment (for intact classes, this will be the total number of students listed in the class, not counting excluded students).

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

$$FW_{st}^{i,j} = A_{st\Delta}^{i,j} \cdot BW_{st\Delta}^{i,j}$$

where Δ equals 1 when there was no student subsampling (intact classes) and 2 when a sample of students was 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:

$$W^{i,j} = FW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}$$

All student data reported in the TIMSS or PIRLS international reports are weighted by the overall student sampling weight, known as TOTWGT in the TIMSS and 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 to participate in TIMSS or PIRLS actually take part in the assessments. To show the level of sampling participation in each country, TIMSS and PIRLS calculate 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 measure of sampling participation.

TIMSS and PIRLS report weighted and unweighted participation rates for schools, classes, and students, as well as 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 together with replacement schools.

Unweighted School Participation Rates

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 50 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 originally sampled and first and second replacement schools.

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

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

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:

$$R_{unw}^{cl} = \frac{\sum_i^{s+rl+r2} c_*^i}{\sum_i c^i}$$

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

UNWEIGHTED STUDENT PARTICIPATION RATES

The unweighted student participation rate is the ratio of the number of students that participated in TIMSS or PIRLS to the total number of students in the participating schools and classes. Classes where less than 50 percent of the students participate 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:

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

OVERALL UNWEIGHTED PARTICIPATION RATES

The overall unweighted participation rate is the product of the unweighted school, class, and student participation rates. Because TIMSS and PIRLS compute 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 originally sampled and first and second replacement schools.

$$R_{unw}^{ov-s} = R_{unw}^{sc-s} \cdot R_{unw}^{cl} \cdot R_{unw}^{st}$$

$$R_{unw}^{ov-r} = R_{unw}^{sc-r} \cdot R_{unw}^{cl} \cdot R_{unw}^{st}$$

WEIGHTED SCHOOL PARTICIPATION RATES

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 TIMSS or 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 originally sampled and first and second replacement schools.

$$R_{wtd}^{sc-s} = \frac{\sum_{i,j}^{s} BW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}}{\sum_{i,j}^{s+rl+r2} FW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}}$$

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

Summations in both the numerator and denominator are over all responding students and include appropriate class and student sampling weights

were used. Note that the basic school weight appears in the numerator, whereas the final school weight appears in the denominator.

WEIGHTED CLASS PARTICIPATION RATES

The weighted class participation rate is computed as follows:

$$R_{wtd}^{cl} = \frac{\sum_{i,j}^{s+rl+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot FW_{st}^{i,j}}{\sum_{i,j}^{s+rl+r2} BW_{sc}^i \cdot FW_{cl}^{i,j} \cdot FW_{st}^{i,j}}$$

where both the numerator and denominator were summations over all responding students from classes with at least 50 percent of their students participating in the study, and the appropriate student-level sampling weights were 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 RATES

The weighted student participation rate is computed as follows:

$$R_{wtd}^{st} = \frac{\sum_{i,j}^{s+rl+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot BW_{st}^{i,j}}{\sum_{i,j}^{s+rl+r2} BW_{sc}^i \cdot BW_{cl}^{i,j} \cdot FW_{st}^{i,j}}$$

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.

WEIGHTED OVERALL PARTICIPATION RATES

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.

$$R_{wtd}^{ov-s} = R_{wtd}^{sc-s} \cdot R_{wtd}^{cl} \cdot R_{wtd}^{st}$$

$$R_{wtd}^{ov-r} = R_{wtd}^{sc-r} \cdot R_{wtd}^{cl} \cdot R_{wtd}^{st}$$

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

References

TIMSS & PIRLS International Study Center. (2008). TIMSS and PIRLS 2011 survey operations procedures unit 1: Sampling schools and obtaining their cooperation. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

TIMSS & PIRLS International Study Center. (2009). TIMSS and PIRLS 2011 survey operations procedures unit 2: Preparing for and conducting the PIRLS 2011 and TIMSS 2011 field test. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

TIMSS & PIRLS International Study Center. (2010). TIMSS and PIRLS 2011 survey operations procedures unit 3: Contacting schools and sampling classes for the TIMSS & PIRLS 2011 data collection. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

UNESCO. (1999). Operational manual for ISCED-1997 (international standard classification of education). Paris: UNESCO Institute of Statistics.