CHAPTER 3

Sample Design in TIMSS Advanced 2015

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Introduction

TIMSS Advanced is 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. The TIMSS Advanced 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. TIMSS Advanced assesses advanced mathematics and physics achievement in the final year of upper secondary schooling for students with advanced preparation in these subjects.

This chapter describes the sample design developed for TIMSS Advanced 2015. It explains how the target populations were defined in the participating countries and how the national sample designs were developed. It also explains how the sampling weights and participation rates are calculated.

National Sampling Plan

Each country participating in TIMSS Advanced needs a plan for defining its national target population and applying the TIMSS Advanced 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 Advanced 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 Advanced standards. In cooperation with sampling staff from the IEA Data Processing and Research Center (IEA 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 Advanced 2015 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 *TIMSS Advanced 2015 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. Within-school sampling procedures for the field test are documented in *TIMSS Advanced 2015 Survey Operations Procedures Unit 2: Preparing for and Conducting the Field Test*. More information on the Survey Operations Units can be found in Chapter 6 of this volume.

The TIMSS Advanced 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 programs, tracks, or courses that correspond to the international target population; create a sampling frame by listing all schools in the population that have classes with advanced mathematics and/or physics students in the target grade; determine national population coverage and exclusions, in accordance with the TIMSS Advanced 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 and the International Sampling Referee, as necessary, to resolve issues and questions. Final approval of TIMSS Advanced 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 TIMSS Advanced 2015 Target Populations

TIMSS Advanced 2015 measured student achievement in two student populations at the end of secondary schooling: advanced mathematics students and physics students. To allow for meaningful interpretation of the TIMSS Advanced 2015 data, and to ensure the comparability of the results across the participating countries, it was important that both target populations be accurately and consistently defined.

The TIMSS Advanced 2015 target population for advanced mathematics was defined as *the students in the final year of secondary schooling who have taken courses in advanced mathematics.* For physics, the TIMSS Advanced 2015 target population was defined as *the students in the final year of secondary schooling who have taken courses in physics.*

Courses in Advanced Mathematics and Physics

The courses that would define the target populations had to cover most, if not all, of the advanced mathematics and physics topics that were outlined in the TIMSS Advanced 2015 Assessment Frameworks. The students attending these courses were likely to be the most advanced mathematics or physics students in the final year of upper secondary schooling in the participating countries. It was the responsibility of the NRCs to identify these advanced mathematics courses and physics courses. In many cases, the courses were found in specific academic programs, or tracks, in upper secondary schools.

In the Russian Federation, TIMSS Advanced 2015 mathematics students assessed include both the Profile and Intensive streams of students. However, results also are provided separately for the students in the Intensive stream because this is the group of students assessed in TIMSS Advanced 1995 and TIMSS Advanced 2008. The results for the Intensive stream students are designated Russian Federation 6hr+.

Exhibit 3.1 and Exhibit 3.2 give an overview of the national target population definitions for advanced mathematics and physics, respectively, in terms of the courses or programs in which the eligible students would be found. In all instances, these students were in their final year of secondary schooling; although this meant the students had varied numbers of years of schooling across the participating countries and were of different average age. Exhibit M1.1 and Chapter M11 of the *TIMSS Advanced 2015 International Report in Advanced Mathematics and Physics* describe the advanced mathematics programs of the upper secondary educational systems in the participating countries, and Exhibit P1.1 and Chapter P11 provide similar descriptions for the physics programs.

Exhibit 3.1: TIMSS Advanced 2015 Advanced Mathematics Populations

Country	Advanced Mathematics Population
France	Students in the 12th grade in the scientific track
Italy	Students in the 13th grade in general schools with scientific focus on mathematics and physics (Liceo Scientifico), in general schools with a focus on science, mathematics, and physics (Liceo Scientifico opzione Scienze Applicate), or in technical institutes and receiving full-time vocational training
Lebanon	Students in the 12th grade in the general science program
Norway	Students in the 13th grade who have taken the Mathematics R2 advanced mathematics course in the academic track
Portugal	Students in the 12th grade in the Sciences and Technology or Socio-Economic programs of the academic track who have taken the Mathematica A advanced mathematics course
Russian Federation	Students in the 11th grade who have taken 4.5 hours or more per week of instruction in mathematics (Profile and Intensive streams)
Russian Federation 6hr+	Students in the 11th grade who have taken 6 hours or more per week of instruction in mathematics (Intensive stream)
Slovenia	Students in the 13th grade in general gymnasia programs
Sweden	Students in the 12th grade in the Natural Science or the Technology programs and have taken or were taking Mathematics 4 and/or Mathematics 5 course
United States	Students in the 12th grade who have taken an advanced mathematics course (AP, IB, or another advanced mathematics course specific to their state/district), in Grade 12 or in a prior grade

Exhibit 3.2: TIMSS Advanced 2015 Physics Populations

Country	Physics Population
France	Students in the 12th grade in the scientific track
Italy	Students in the 13th grade in general schools with scientific focus on mathematics and physics (Liceo Scientifico), in general schools with a focus on science, mathematics, and physics (Liceo Scientifico opzione Scienze Applicate), or in technical institutes and receiving full-time vocational training
Lebanon	Students in the 12th grade in the general science program
Norway	Students in the 13th grade of the academic track who have taken the Physics 2 course
Portugal	Students in the 12th grade in the Sciences and Technology program of the academic track who have taken physics courses
Russian Federation	Students in the 11th grade who have taken 4.5 hours or more per week of instruction in mathematics (Profile and Intensive streams)
Slovenia	Students in the 13th grade in general gymnasia programs
Sweden	Students in the 12th grade in the Natural Science or the Technology programs and have taken or were taking Mathematics 4 and/or Mathematics 5 course
United States	Students in the 12th grade who have taken an advanced mathematics course (AP, IB, or another advanced mathematics course specific to their state/district), in Grade 12 or in a prior grade

TIMSS Advanced Coverage Indices

In order to quantify the proportion of the school-leaving age cohort taking advanced mathematics and physics courses, TIMSS Advanced computed a TIMSS Advanced Mathematics Coverage Index (TAMCI) and a TIMSS Advanced Physics Coverage Index (TAPCI) for each participating country. In part, these indices reflect the overall sampling coverage of the respective populations in each country; but, more importantly, they show that only a very select group of final-year students were considered eligible for TIMSS Advanced 2015, and that the percentages of these students varied across countries.

The TIMSS Advanced coverage indices for advanced mathematics and physics were defined as follows:

$$\text{TAMCI} = \frac{\text{Estimated total number of students in the advanced mathematics population}}{\text{Total national population in the corresponding age cohort}} \times 100\%$$

$$\text{TAPCI} = \frac{\text{Estimated total number of students in the physics population}}{\text{Total national population in the corresponding age cohort}} \times 100\%$$

The numerator in each index is the total number of students eligible for TIMSS Advanced 2015, either for advanced mathematics or physics, as estimated from the weighted samples. The denominator is an estimate of the size of the eligible age cohort in 2015 corresponding to the mean age of the target population. The TIMSS Advanced coverage indices for advanced mathematics and physics are presented in Exhibits 3.3 and 3.4. The final-year age cohort for each country was defined to be the age corresponding to its average age at the time of testing, as estimated from the weighted samples, and its size was estimated from national census figures. The estimated target populations were estimated from the weighted samples.

Exhibit 3.3: Size of TIMSS Advanced 2015 Target Population for Advanced Mathematics, the Age Cohort, and the TIMSS Advanced Coverage Index for Advanced Mathematics

Country	Years of Formal Schooling*	Age Cohort Corresponding to the Final Year of Secondary School	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Advanced Mathematics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures**	TIMSS Advanced Mathematics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population
France	12	18	172,178	801,889	21.5%
Italy	13	19	141,419	576,506	24.5%
Lebanon	12	18	4,457	113,204	3.9%
Norway	13	19	6,751	63,894	10.6%
Portugal	12	18	31,314	109,984	28.5%
Russian Federation	11	18	138,548	1,365,790	10.1%
Russian Federation 6hr+	11	18	25,830	1,365,790	1.9%
Slovenia	13	19	6,738	19,598	34.4%
Sweden	12	19	15,285	108,138	14.1%
United States	12	18	473,405	4,168,000	11.4%

* Represents years of schooling counting from the first year of primary or basic education (first year of ISCED Level 1).

** France: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INSEE (National Institute of Statistics and Economic Studies), Estimations de Population (résultats provisoires à fin 2015); http://www.insee.fr/fr/themes/detail.asp?reg_id=99&ref_id=estim-pop.

Italy: Value is the total population of 19-year olds in Italy in 2015. Data retrieved from ISTAT (the National Statistics Institute); http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1.

Lebanon: Value is the total population of 18-year olds in Lebanon in 2015. Data retrieved from http://databank.worldbank.org/data/reports.aspx?source=health-nutrition-and-population-statistics:-population-estimates-and-projections&Type=TABLE&preview=on.

Norway: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=POP_PROJ.

Portugal: Estimate derived by dividing the 2014 population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INE (Instituto Nacional de Estatística) Annual Estimates of Resident Population; http://www.pordata.pt/en/Portugal/Resident+population+total+and+by+age+group-10.

Russian Federation: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from The Demographic Yearbook of Russia, 2015; http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1137674209312.

Slovenia: Value is the total population of 18-year olds in Slovenia as of July 1st 2015. Data retrieved from the Statistical Office of the Republic of Slovenia; http://pxweb.stat.si.

Sweden: Value is the total population of 18-year olds as of December 31, 2014 (Born 1996). Data retrieved from Statistics Sweden; http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningR1860/table/tableViewLayout1/?rxid=06695d79-5fa1-41d1-81c1-3ae51dcd09b7.

United States: Value is the total population of 18-year olds as of July 1st 2015. Data retrieved from the US Census Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2013; https://www.census.gov/popest/data/national/asrh/2013/. The post-census estimates are as of July 1 of each year. For the 18 year-olds estimate in 2015, the 2015 population was projected using the year to year changes from 2010 to 2013 and extending it to 2015.

The TIMSS Advanced Mathematics Coverage Index reflects the differences across countries in the proportion of the age cohort that are enrolled in these advanced courses the final year of secondary education. In some countries, only a very select group of students was considered eligible for the study, while in others, a much larger group was included.

The TIMSS Advanced Mathematics Coverage Index (TAMCI) is defined as follows:

$$\text{TAMCI} = \frac{\text{Estimated total number of students in the advanced mathematics target population in 2015}}{\text{Total national population in the corresponding age cohort in 2015}} \times 100\%$$

The numerator is the total number of students eligible for TIMSS Advanced, estimated from the weighted sample data. These are students in the final year of secondary school taking the advanced mathematics track or program targeted by TIMSS Advanced, based on the TIMSS Advanced sample. The denominator is the size of the population age cohort corresponding to the average age of the students in the target populations and is based on national census figures.

Exhibit 3.4: Size of TIMSS Advanced 2015 Target Population for Physics, the Age Cohort, and the TIMSS Advanced Coverage Index for Physics

Country	Years of Formal Schooling*	Age Cohort Corresponding to the Final Year of Secondary School	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Physics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures**	TIMSS Advanced Physics Coverage Index– the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population
France	12	18	172,178	801,889	21.5%
Italy	13	19	104,650	576,506	18.2%
Lebanon	12	18	4,464	113,204	3.9%
Norway	13	19	4,163	63,894	6.5%
Portugal	12	18	5,661	109,984	5.1%
Russian Federation	11	18	66,746	1,365,790	4.9%
Slovenia	13	19	1,491	19,598	7.6%
Sweden	12	19	15,423	108,138	14.3%
United States	12	18	199,944	4,168,000	4.8%

* Represents years of schooling counting from the first year of primary or basic education (first year of ISCED Level 1).

** France: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INSEE (National Institute of Statistics and Economic Studies), Estimations de Population (résultats provisoires à fin 2015); http://www.insee.fr/fr/themes/detail.asp?reg_id=99&ref_id=estim-pop.

Italy: Value is the total population of 19-year olds in Italy in 2015. Data retrieved from ISTAT (the National Statistics Institute); http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1.

Lebanon: Value is the total population of 18-year olds in Lebanon in 2015. Data retrieved from http://databank.worldbank.org/data/reports.aspx?source=health-nutrition-and-population-statistics:-population-estimates-and-projections&Type=TABLE&preview=on.

Norway: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=POP_PROJ.

Portugal: Estimate derived by dividing the 2014 population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INE (Instituto Nacional de Estatística) Annual Estimates of Resident Population; http://www.pordata.pt/en/Portugal/Resident+population+total+and+by+age+group-10.

Russian Federation: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from The Demographic Yearbook of Russia, 2015; http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1137674209312.

Slovenia: Value is the total population of 18-year olds in Slovenia as of July 1st 2015. Data retrieved from the Statistical Office of the Republic of Slovenia; http://pxweb.stat.si.

Sweden: Value is the total population of 18-year olds as of December 31, 2014 (Born 1996). Data retrieved from Statistics Sweden; http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningR1860/table/tableViewLayout1/?rxid=06695d79-5fa1-41d1-81c1-3ae51dcd09b7.

United States: Value is the total population of 18-year olds as of July 1st 2015. Data retrieved from the US Census Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2013; https://www.census.gov/popest/data/national/asrh/2013/. The post-census estimates are as of July 1 of each year. For the 18 year-olds estimate in 2015, the 2015 population was projected using the year to year changes from 2010 to 2013 and extending it to 2015.

The TIMSS Advanced Physics Coverage Index reflects the differences across countries in the proportion of the age cohort that are enrolled in these advanced courses in the final year of secondary education. In some countries, only a very select group of students was considered eligible for the study, while in others, a much larger group was included.

The TIMSS Advanced Physics Coverage Index (TAMCI) is defined as follows:

$$\text{TAMCI} = \frac{\text{Estimated total number of students in the physics target population in 2015}}{\text{Total national population in the corresponding age cohort in 2015}} \times 100\%$$

The numerator is the total number of students eligible for TIMSS Advanced, estimated from the weighted sample data. These are students in the final year of secondary school taking the physics track or program targeted by TIMSS Advanced, based on the TIMSS Advanced sample. The denominator is the size of the population age cohort corresponding to the average age of the students in the target populations and is based on national census figures.

National Coverage and Exclusions

TIMSS Advanced is designed to describe and summarize student achievement across the entire defined target populations, 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
- Providing instruction solely to students in the student-level exclusion categories listed below (i.e., catering only to special needs students)

Student Level Exclusions. As in TIMSS, students with functional or intellectual disabilities as well as non-native language speakers within each school can be excluded. However, in specialized target populations such as in TIMSS Advanced, such exclusions are uncommon.

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.

Further details on the national coverage and exclusions for each country can be found in the Characteristics of National Samples appendix to Chapter 5: Sampling Implementation.

Requirements for Sampling the Target Population

TIMSS Advanced sets 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 Sizes

Because TIMSS Advanced is fundamentally a study of student achievement, the precision of estimates of student achievement is of primary importance. To meet the TIMSS Advanced 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 Advanced 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 Advanced 2008 and 2015). Sample estimates of any student-level percentage estimate (e.g., a student background characteristic) should have a confidence interval of ±3.5%.

With this in mind, and taking into account the clustered nature of the samples and the added uncertainty stemming from the imputation used in scaling the achievement data (see Chapter 4), the minimum sample sizes required 4,000 tested students for advanced mathematics and 4,000 for physics, selected from a minimum of 150 schools. These minima were fixed after looking at the sample sizes and precision achieved with the TIMSS Advanced 2008 results. As these were minima, most countries increased their sample sizes to account for non-response. For the Russian Federation, the sample size was increased because of the additional clustering effect due to sampling regions before sampling schools. The selected and achieved national school sample sizes are presented in Appendix 5A: National Characteristics.

Field Test Sample

Prior to the TIMSS Advanced 2015 data collection, an extensive field test is conducted in all participating countries. The goal of this field test is to check all instruments—particularly the achievement tests—and operational procedures under conditions similar to those of the data collection. 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 assessment booklets being field tested. The TIMSS Advanced 2015 field test had four assessment booklets and so required a field test sample of 800 students for each subject.

Participation Rates

To minimize the potential for non-response bias, TIMSS Advanced aims 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.

TIMSS Advanced 2015 proposed a uniform sample design to all participants to ensure that differences in survey results were not attributable to the use of different sampling methodologies. This uniform sample design was flexible enough to accommodate the distinctiveness of national school systems at the upper secondary level and how the target populations were defined across participating countries. All sample designs were approved by Statistics Canada.

The TIMSS Advanced Sample Design

The basic TIMSS Advanced 2015 sample design consisted of two sampling stages: schools were sampled at the first stage, and one or more intact classes of students were sampled from a list of eligible classes within a selected school at the second stage.

First Sampling Stage. Two methods were used to sample schools in TIMSS Advanced 2015. In countries where the number of schools in the population greatly exceeded the number required in the sample, a systematic probability-proportional-to-size (PPS) sampling method was used.

This method, followed by the selection of classes within the selected schools in a second sampling stage, is often referred to as systematic two-stage PPS sampling and is described in most sampling textbooks (e.g., Cochran 1977, Lohr 1999). The PPS sampling approach was used in France, Italy, Portugal, the Russian Federation, and the United States. In other countries, where the number of schools to sample from was relatively small, schools were sampled with equal probabilities. This was the case in Norway, and Sweden. In Lebanon and Slovenia, all schools were selected.

Second Sampling Stage. In all but one country, classes within selected schools were sampled using a random systematic sampling method. The only exception was in the United States where students were grouped according to whether they were in advanced mathematics and/or physics target population(s) and sampled directly using a random systematic sampling approach.

National sample designs had to take into account the expected overlap across the advanced mathematics and physics populations. In some countries, students in a specific program belonged to both advanced mathematics and physics populations. In other countries, eligible students were found in two programs: students in one program belonged to both populations, while students from the other program belonged only to the advanced mathematics population. Finally, in a third set of countries, students were free to choose the courses they took and thus the degree of overlap between the two populations could not be predicted. Thus, two principal sample designs—a single school sample and separate school samples—were developed. While countries that participated in TIMSS Advanced 2015 adopted one of these two sample designs, some opted for slight modifications to account for particular national circumstances.

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 Advanced include region of the country (e.g., states or provinces); school type or source of funding (e.g., public or private); and school performance on national examinations.

In TIMSS Advanced, stratification is used to:

- Separate schools according to the populations found in schools—schools with advanced mathematics only, physics only, or with both populations
- 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. For example, the sampling frame for Norway was divided into a total of five explicit strata based on the populations present and the size of the schools.

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.

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

Exhibits 3.5 and 3.6 provide the list of explicit and implicit stratification variables implemented by the participating countries for advanced mathematics and physics. Further details on the explicit and implicit stratification variables for each country can be found in Appendix 5A: Characteristics of National Samples in Chapter 5: Sampling Implementation for TIMSS Advanced 2015.

Exhibit 3.5: TIMSS Advanced 2015 Advanced Mathematics Stratification Variables

Country	Explicit Stratification Variables	Number of Explicit Strata	Implicit Stratification Variables
France	School type (2) Success rate level (5)	8	None
Italy	School type (2) Region (5)	10	None
Lebanon	School type (2)	2	Region (7)
Norway	School size (5)	5	None
Portugal	School type (2) Region (7)	8	None
Russian Federation	Region (28) Presence of advanced mathematics streams (3)	77	Region (14) Location (9)
Russian Federation 6hr+	Presence of students from two advanced mathematics streams (3) Region (27)	48	Region (14) Location (9)
Slovenia	Presence of students from the two study populations (2) Percentage of mathematics experts in school	4	None
Sweden	Programs offered (3) School size (3)	9	School type (2)
United States	Presence of advanced program (2) School type (2) Census Region (4)	9	Urbanization (4) Ethnicity status (2)

Exhibit 3.6: TIMSS Advanced 2015 Physics Stratification Variables

Country	Explicit Stratification Variables	Number of Explicit Strata	Implicit Stratification Variables
France	School type (2) Success rate level (5)	8	None
Italy	Region (5)	5	None
Lebanon	School type (2)	2	Region (7)
Norway	School size (4)	4	None
Portugal	School type (2) Region (7)	8	None
Russian Federation	Region (all certainty, sampled) (28)	29	Region (14) Location (9)
Slovenia	Percentage of mathematics experts in school (3)	3	None
Sweden	Programs offered (3) School size (3)	9	School type (2)
United States	Presence of advanced program (2) School type (2) Census Region (4)	9	Urbanization (4) Ethnicity status (2)

Sample Design for Completely Overlapping Populations

This sample design was implemented in countries where there was complete overlap of both the advanced mathematics and physics populations and consisted of selecting a single sample of schools and one or more classes for both populations. Students in each sampled class were randomly assigned an advanced mathematics booklet or a physics booklet. Consequently, about half of the students received an advanced mathematics booklet while the other half received a physics booklet. France and Lebanon implemented this design.

Sample Design for Partially Overlapping Populations

This sample design was implemented in countries where students belonged to either, or even both, populations with no discernible pattern as students were free to choose which courses they would attend. In order to streamline the within-school operations and avoid testing students twice, this sample design consisted of selecting two separate school samples whenever possible. Both samples of schools were selected simultaneously to prevent overlap or were selected sequentially, while minimizing the overlap between both samples. In one school sample, only the advanced mathematics classes were listed for class sampling, and students in the sampled classes were assigned one of the six advanced mathematics booklets. In the other school sample, only physics classes were listed for class sampling, and students in the sampled classes were assigned one of the six physics booklets. Two separate samples were selected for Norway, Sweden, and the United States. In Norway and Sweden, both school samples were selected simultaneously while they were selected sequentially in the Russian Federation. In Italy, Portugal, Slovenia, and the United States, it was not possible to select separate school samples for each subject and the special adaptations made to the two principal sample designs for these countries are described below.

Special Adaptation for the Russian Federation

In the Russian Federation, a sample of regions was selected prior to the sampling of schools. Approximately half of the regions were sampled. Regions were selected with probability proportional to size, the largest regions being sampled with certainty. Thus, the sample of regions consisted of a group of certainty regions and a group of sampled regions. In a second stage, the school sample for the advanced mathematics population was selected.

From the group of certainty regions, all schools were grouped into three explicit strata, regardless of region, according to the type of students found in the schools: schools with the Intensive stream classes only, with the Profile stream classes only, or schools with classes from both streams. Regions were used as implicit strata within each explicit stratum. The sample of schools for advanced mathematics was selected among the three different strata.

For the group of sampled regions, the sampling of schools was done within each sampled region individually—regions being the primary sample units—and schools within each sampled region were split into the same three strata by the type of classes found in the schools, as was done in schools from the certainty regions. The sample of schools for advanced mathematics was selected among the three different strata from each sampled region.

Following the selection of the advanced mathematics sample, the next step was to select the physics school sample while minimizing the overlap with the advanced mathematics school sample. The overlap control was done using the technique described in Chowdhury, Chu, and Kaufman (2000)—more information on this technique can be found in Appendix 3B of *Methods and Procedures in TIMSS 2015*. Schools from the certainty regions were grouped to form one large stratum and implicitly sorted by region. A sample of schools for physics was selected from that stratum, minimizing the overlap with the advanced mathematics school sample.

For the group of sampled regions, the sampling of schools for physics was done within each sampled region individually, regions being the primary sample units. A sample of schools for physics was selected from each sampled region, minimizing the overlap with the advanced mathematics school sample.

Special Adaptation for Italy

In Italy, the structure of advanced mathematics and physics education and the sample size restrictions required a combination of the two established sample designs. Courses of interest were found in two types of schools: Technical Institutes with advanced mathematics classes only and Scientific Lyceum in which both subjects are compulsory. Schools were split in two groups according to their type and the sample selection was done simultaneously for both subjects. For the advanced mathematics assessment, the sample was composed of schools from both groups while for the physics assessment, the sample was drawn only from the Scientific Lyceum group. To reach the required sample size for each target population, all schools sampled from the Scientific Lyceum group were assigned to the physics assessment while only a sub-sample of these schools were randomly selected for the advanced mathematics assessment. In schools selected for both subjects, students in each sampled class were randomly assigned an advanced mathematics booklet or a physics booklet. Consequently, about half of the students received an advanced mathematics test booklet while the other half received a physics test booklet. In the other schools, students were only sampled for one subject, and as such only this subjects booklets were rotated within classes.

Special Adaptation for Portugal

In Portugal, school sample size restrictions and the structure of advanced mathematics and physics education also required a combination of the two established sample designs. Two groups of schools were identified based on the information provided on the sampling frame: schools with advanced mathematics students only and schools with a mixture of students (advanced mathematics students only and advanced mathematics and physics students). The sample selection was done simultaneously for both subjects. For the advanced mathematics assessment, the sample was composed of schools from both groups while for the physics assessment, the sample was drawn only from the latter group. All schools selected from the advanced mathematics and physics group were selected for both subjects.

In schools sampled for advanced mathematics, the regular approach of rotating the advanced mathematics booklets within the sampled classes was used. In schools selected for both subjects, two groups of classes were identified: one group of classes with advanced mathematics only students and one group of classes with advanced mathematics and physics students. In classes selected from the first class group, students were assessed only for advanced mathematics. In classes selected from the second class group, booklets from both subjects were randomly assigned to each student. To meet the sample size requirements for each subject and to preserve the proportion of students belonging to each group within school, one out of six students were randomly assigned an advanced mathematics booklet while the remaining students received a physics booklet.

The classification of schools to advanced mathematics only or to both subjects was done using a school sampling frame from a previous school year. During data collection, physics students were found in a number of schools assigned to the advanced mathematics only group. Also, some schools assigned to the advanced mathematics and physics assessments did not have any physics students. Therefore, all sampled schools were considered eligible for both populations regardless of their initial classification to one group or the other.

Special Adaptation for Slovenia

In Slovenia, the relatively small student populations made it impossible to meet the TIMSS Advanced 2015 student sample size requirements with either of the two standard sample designs. In particular, all physics students in the country had to be selected. Moreover, all schools were selected for both subjects given the small number of schools in the country.

In each school, the advanced mathematics classes and the physics classes were listed separately. A sample of classes was drawn from the list of advanced mathematics classes while all classes from the list of physics classes were selected. Since some students in the selected physics classes could have been sampled for advanced mathematics as well, some students were assessed for both subjects. The order in which the two assessments was administered was determined randomly in each school.

Special Adaptation for the United States

In the United States, the structure of advanced mathematics and physics education required a direct student sampling approach. Within sampled schools, students were assigned to one of three groups: the advanced mathematics group only, the physics group only, or the advanced mathematics and physics group. The advanced mathematics sample was composed of students sampled from the first and third group while the physics sample was composed of students sampled from the second and third group. Students selected from the advanced mathematics group were randomly assigned an advanced mathematics booklet. Students selected from the physics group were randomly assigned a physics booklet. Students selected from the advanced mathematics and physics group were randomly assigned an advanced mathematics booklet or a physics booklet. Consequently, about half of the students from this third group received an advanced mathematics booklet while the other half received a physics booklet.

Further details on the sample design for each country can be found in Appendix 5A: Characteristics of National Samples in Chapter 5: Sampling Implementation for TIMSS Advanced 2015.

Replacement Schools

Ideally, all schools sampled for TIMSS Advanced should participate in the assessments, and NRCs 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 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 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 Advanced 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. Only after all attempts to persuade a sampled school to participate have failed is the use of its replacement school considered.

This strategy was implemented in France, Italy, Portugal, the Russian Federation, and the United States. In Lebanon and Slovenia, there were no replacement schools, as all eligible schools were in the sample for both populations. In Norway and Sweden, since all schools were selected for the advanced mathematics sample or for the physics sample, there were no replacement schools available either.

Calculating Sampling Weights

National student samples in TIMSS Advanced 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.

The student sampling weight in TIMSS Advanced 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). For some countries, additional adjustments were required to account for additional sampling steps.

Note that sampling weights are calculated independently for each TIMSS Advanced population and within each explicit stratum. Thus a country will have only one set of sampling weights per target population (advanced mathematics and physics).

School Weighting Component

When schools are sampled with probability proportional to school size, the basic school weight for the i^{th} sampled school of population g (where g takes the value M for advanced mathematics and P for physics) is defined as:

$$BW_{sc}^{g,i} = \frac{MOS}{n \cdot MOS_i}$$

where n was the number of sampled schools in population g, mos_i was the measure of size for the i^{th} school, and

$$MOS = \sum_{i=1}^{N} mos_i$$

where N was the total number of schools in the explicit stratum of population g.

In France, Italy, Portugal, the Russian Federation, and the United States, the school selection probabilities were proportional to school size, generally defined as the number of students in the target population.

In Norway and Sweden, equal probability sampling of schools, rather than PPS, was carried out, meaning that every school had the same measure of size ($mos_i = 1$). Thus the school weight for the i^{th} sampled school in population g in these countries was calculated as:

$$BW_{sc}^{g,i} = \frac{N}{n}$$

In Lebanon a census of schools was taken resulting in a school weight equal to unity.

Special School Weight Factor for Italy

As was mentioned earlier, special weight factors or adjustments were calculated to account for additional sampling steps introduced during school sampling and arising from special adaptations to national sample designs in some countries.

In Italy, while all 120 schools sampled from stratum of schools with the advanced mathematics and physics program (scientific lyceum school stratum) were assigned to the physics population, 88 of them were randomly sub-sampled for the advanced mathematics population. Thus, an additional weight factor for the sub-sampled schools in advanced mathematics was computed as the inverse of the probability of a school sampled from this stratum being selected for advanced mathematics, and the original school weight was multiplied by this additional weight factor.

Special Weight Factors for the Russian Federation

The sample design for the Russian Federation included a preliminary sampling stage, in which regions were sampled. Thus, the school weight also incorporated the probability of selection in this preliminary stage, and the school weight for all schools from the Russian Federation was the product of the "region" weight and the school weight described earlier. This region weight was computed in a manner similar to the school weight, with regions having selection probabilities proportional to their size.

School Nonparticipation Adjustment

If a sampled school does not participate in TIMSS Advanced 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 and each population g, as follows:

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

where n_s was 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} the number of schools that did not participate and were not replaced. Sampled schools that are found to be ineligible[1] are not included in the calculation of this adjustment.

Combining the basic school weight and the school nonparticipation adjustment, the final school weighting component assigned to all students in the i^{th} school of population g ($g = M$ or P), corrected for non-participating schools, becomes:

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

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

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 TIMSS Advanced, one or two classes are sampled with equal probability from the list of all eligible classes in the school for population g. 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. In countries where schools were sampled with probabilities proportional to school size, this relatively greater selection probability for students in small schools offsets the lower selection probability at the first stage as sampling results in higher selection probabilities for larger schools.

1 A sampled school is ineligible if it is found to contain no eligible students (i.e., no students in the target population). Such schools usually are in the sampling frame by mistake or are schools that do not offer advanced programs anymore.

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} school sampled for population g, let $C^{g,i}$ be the total number of eligible classes and $c^{g,i}$ the number of sampled classes. Using equal probability sampling, the basic class weight for all sampled classes in the i^{th} school for population g is:

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

For most TIMSS Advanced participants, $c^{g,i}$ takes the values 1 or 2. Some TIMSS Advanced participants sampled all eligible classes in a selected school, in which case $c^{g,i}$ is equal to $C^{g,i}$.

In Sweden, when appropriate, classes within the sampled schools were grouped by program prior to sampling and one class (or more) was randomly selected from each class group. In Portugal, classes were also grouped in two different class groups according to the student type (advanced mathematics only or advanced mathematics and physics). As a result, the basic class weight was computed separately for each class group within the sampled schools in these two countries. For the United States, since direct student sampling was performed, the class weight was set to unity.

Class Nonparticipation Adjustment

Basic class weights are calculated for all sampled classes in the sampled and replacement schools that participate in TIMSS. 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:

$$A_{cl}^{g} = \frac{\sum_{i}^{s+r1+r2} 1}{\sum_{i}^{s+r1+r2} \delta^{g,i}/c^{g,i}}$$

where $c^{g,i}$ is the number of sampled classes in the i^{th} school for population g, as defined earlier, and $\delta^{g,i}$ gives the number of participating classes in the i^{th} school of population g within the explicit stratum.

Combining the basic class weight and the class nonparticipation adjustment, the final class weighting component, assigned to all sampled classes in the ith school of population g becomes:

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

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.

By design, all students within selected classes are selected for the TIMSS Advanced 2015 assessments. In most cases, they are all assigned a booklet from one subject—either advanced mathematics or physics. In countries with completely overlapping populations, however, roughly half of the students in a class are assigned a booklet in one subject and the other half in the other subject.

The basic student weight for the j^{th} class in the ith school of population g is calculated as follows:

$$BW_{st}^{g,i,j} = \frac{n^{i,j}}{n^{g,i,j}}$$

where the $n^{i,j}$ is the total number of students in the j^{th} class of the ith school and $n^{g,i,j}$ is the number of students in that class selected for population g ($g = M \text{ or } P$).

When classes are sampled for only one population, then $n^{g,i,j}$ is equal to $n^{i,j}$ and the probability of a student in a selected class being sampled for that population is unity. When booklets from both populations are distributed among students from a selected class, this probability is approximately one half. In both cases, the student weight is calculated separately for each selected class and for each population.

As mentioned in the sample design section, direct student sampling was used for the United States. Students were assigned to one of three groups: the advanced mathematics group only, the physics group only, or the advanced mathematics and physics group. The student weight was computed as the inverse of the probability of a student being sampled for a specific subject from each group.

Student Nonparticipation Adjustment

The student nonparticipation adjustment for the j^{th} class in the ith school of population g is calculated as:

$$A_{st}^{g,i,j} = \frac{s_{rs}^{g,i,j} + s_{nr}^{g,i,j}}{s_{rs}^{g,i,j}}$$

where $s_{rs}^{g,i,j}$ is the number of participating students (i.e., students that participated in TIMSS Advanced and have assessment scores for their assigned population g) in the j^{th} class of the i^{th} school, and $s_{nr}^{g,i,j}$ is the number of students sampled in this class who were expected to have assessment scores for their assigned population g but did not participate in the assessment. This adjustment is calculated in the same manner, regardless whether a class was selected for a single population or for both populations.

The final student weighting component for students selected for population g in the j^{th} class of the i^{th} school is:

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

Overall Student Sampling Weight

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

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

Overall student sampling weights are only attributed to participating students, with non-participants weighted at 0. All student data reported in the TIMSS Advanced international reports are weighted by the overall student sampling weight, known as TOTWGT in the TIMSS Advanced 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 Advanced actually take part in the assessments. To show the level of sampling participation in each country, TIMSS Advanced 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 measure of sampling participation.

TIMSS Advanced reports 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 for each population as follows:

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

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

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

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

Unweighted Class Participation Rates

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

$$R_{unw}^{g,cl} = \frac{\sum_{i}^{s+r1+r2} c_{*}^{g,i}}{\sum_{i}^{s+r1+r2} c^{g,i}}$$

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

Unweighted Student Participation Rates

The unweighted student participation rate is the ratio of the number of selected students that participated in TIMSS Advanced to the total number of selected students that should have been assessed 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 for population g is computed as follows:

$$R_{unw}^{g,st} = \frac{\sum_{i}^{s+r1+r2} s_{rs}^{g,i,j}}{\sum_{i}^{s+r1+r2} \left(s_{rs}^{g,i,j} + s_{nr}^{g,i,j}\right)}$$

Overall Unweighted Participation Rates

The overall unweighted participation rate is the product of the unweighted school, class, and student participation rates. Because TIMSS Advanced 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:

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

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

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

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

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 Advanced 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:

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

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

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

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

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 Rates

The weighted class participation rate for each population is computed as follows:

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

where both the numerator and denominator are 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 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 Rates

The weighted student participation rates for each population *g* is computed as follows:

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

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.

Overall Weighted 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:

$R_{wtd}^{g,ov-s}$ = weighted overall participation rate from sampled schools only

$R_{wtd}^{g,ov-r}$ = weighted overall participation rate from sampled and replacement schools

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

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

Weighted school, class, student, and overall participation rates are computed for each TIMSS Advanced participant, for each population *g*, using these procedures.

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