CHAPTER 3

TIMSS Sample Design

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Introduction

TIMSS is designed to provide valid and reliable measurement of trends in student achievement in countries around the world, while keeping the burden on schools, teachers, and students to a minimum. To ensure the quality and validity of TIMSS results, participating countries follow carefully delineated procedures in each assessment cycle to develop and implement national sampling plans according to standards and specifications set for the target populations, sampling precision, and sample selection methods.

The TIMSS 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 assesses mathematics and science achievement at two grade levels. Hence, TIMSS has two target populations—all students enrolled at the fourth grade and all students enrolled at the eighth grade, counting from the first year of primary schooling. Countries may assess either one or both student populations.

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

This chapter describes the international target population and sampling design aspects guiding national sample selection for TIMSS assessment cycles, including the procedures and guidelines for developing, implementing, and documenting national sampling plans and calculating sampling weights for use in the analysis. Chapter 9 documents the national sample characteristics and sampling outcomes for each participating country.

National Sampling Plans

Each country participating in TIMSS needs a plan to define its national target populations and apply the TIMSS sampling methods to achieve a nationally representative sample of schools and students. The development and implementation of the national sampling plan is a collaborative

effort involving the country's National Research Coordinator (NRC) and the Sampling Team for each TIMSS assessment cycle, composed of sampling experts from RTI International and IEA Hamburg.

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

In cooperation with the TIMSS & PIRLS International Study Center, the Sampling Team provides NRCs with a series of manuals to guide them through the sampling process. More specifically, *TIMSS 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 Survey Operations Procedures Unit 3: Contacting Schools and Sampling Classes* 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 Survey Operations Procedures Unit 2A: Sampling Classes and Field Test Administration*. More information on the Survey Operations units can be found in Chapter 4 of this volume.

The TIMSS NRCs are responsible for providing the Sampling Team with all information and documentation necessary to conduct the national sampling and for conducting all sampling operations in their country. For each target grade assessed by a country for a TIMSS assessment cycle, the NRCs are expected to identify the grade that corresponds to the international target population and to create a sampling frame by listing all schools in the population that have classes with students in the target grade; determine national population coverage and exclusions, in accordance with the TIMSS international guidelines; work with the Sampling Team to develop a national sampling plan and identify suitable stratification variables, ensuring that these variables are present and correct for all schools; contact all sampled schools and secure their participation; keep track of school participation and the use of replacement schools; and conduct all within-school sampling of classes. As described in this chapter, each NRC is required to complete a series of sampling forms to document the completion of each task.

A vital feature of the sampling process is one or more meetings between each NRC, members of the NRC's TIMSS team (as needed), and the TIMSS Sampling Team. At these meetings, each step of the sampling process is documented and reviewed in detail, and NRCs can raise issues and ask questions about their national situation and any challenges they

face. The Sampling Team consults with the TIMSS & PIRLS International Study Center and an International Sampling Referee, as necessary, to resolve issues and questions. Final approval of TIMSS national sampling plans is the responsibility of the TIMSS & PIRLS International Study Center, based upon the advice of the Sampling Team and the International Sampling Referee.

Defining the Target Population

As an international comparative study of student achievement in mathematics and science, TIMSS defines its international target populations in terms of how much schooling students have received. The number of years of formal schooling is the basis of comparison among participating countries. Thus, the TIMSS international target population at the fourth grade is all students in their fourth year of formal schooling, and at the eighth grade, all students in their eighth year. UNESCO's International Standard Classification of Education (ISCED) 2011 (UNESCO, 2012) provides an internationally accepted classification scheme for describing levels of schooling across countries. The ISCED system describes the full range of schooling, from pre-primary (Level 0) to the doctoral level (Level 8). ISCED Level 1 corresponds to primary education or the first stage of basic education. The first year of Level 1 "coincides with the transition point in an education system where systematic teaching and learning in reading, writing, and mathematics begins" (UNESCO, 2012, p. 30). Four years after this would be the fourth-grade TIMSS target grade, which is most countries' fourth grade. 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.

Given the cognitive demands of the assessments, TIMSS wants to avoid assessing very young students. Thus, TIMSS recommends assessing the next higher grade (i.e., fifth grade for 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:** 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:** 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

Regardless of age, all students enrolled in the target grade belong to the international target population and should be eligible to participate in TIMSS. Because students are sampled in two stages, first by randomly selecting schools and then by randomly selecting classes from within sampled schools, it is necessary to identify all schools in which eligible students are enrolled. Essentially, eligible schools for TIMSS are those that have any students enrolled in the target

grade, regardless of the 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 grades for TIMSS are the fourth and eighth grades. However, because educational systems vary in structure and policies and practices concerning age of school entry as well as promotion and retention, there are differences across countries in how the target grades are labeled 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. An example of a completed Sampling Form 1 is presented in Exhibit 3.1.

There are countries where students in the fifth grade are more likely to have developed the mathematics and science competencies necessary for success on the TIMSS fourth-grade assessment or in the ninth grade for the TIMSS eighth-grade assessment. Such countries may participate in TIMSS at a grade higher than the international target population. Under these circumstances, countries assessing grades other than the fourth or eighth grade are labeled accordingly in the TIMSS results reports.

Exhibit 3.1: Example of Sampling Form 1

Sampling Form 1 — **General Information**

See Section 2 of TIMSS 2023 Survey Operations Procedures Unit 1

TIMSS 2023 Participant :	*Country X*
National Research Coordinator :	*Name of NRC*

1. Please indicate the assessment(s) in which your country plans to participate along with the target grade(s), name(s), and expected average age of students at the time of testing:

Grade 4 TIMSS Assessment	*Yes*

Target Grade	Name of the Target Grade	Average Age
4	*Grade 4*	*9.7*

Grade 8 TIMSS Assessment	*Yes*

Target Grade	Name of the Target Grade	Average Age
8	*Grade 8*	*13.7*

2. Are you administering the proposed digital assessments (TIMSS) or have you discussed with the TIMSS & PIRLS International Study Center to only administer the trend blocks on paper (Paper-TIMSS)?

TIMSS

3. Specify the usual start and end date(s) of the school year and the expected date(s) of testing for the field test and data collection.

	Start of school year: *(YYYY-MM-DD)*	End of school year: *(YYYY-MM-DD)*	Expected Testing Period
Field Test	*9/5/2021*	*6/22/2022*	*16 - 27 April 2022*
Data Collection	*9/1/2022*	*6/21/2023*	*6 - 30 April 2023*

4. Specify the language(s) in which the assessment(s) will be administered.

English

5. Describe the grade structure through ISCED Level 1 (primary education or the first stage of basic education) and ISCED Level 2 (basic or lower secondary education) in your country.

Grades 1 to 6 , Primary schools
Grades 7 to 9 , Lower secondary schools

6. Describe the age and birth date rules for entering ISCED Level 1 in your country.

Children must enter school (grade 1) in the autumn of the year in which they have their sixth birthday

National Coverage and Exclusions

TIMSS is designed to describe and summarize student achievement across the entire target grade (fourth or eighth), so national target populations must aim for comprehensive coverage of eligible students. However, in some cases, political, organizational, or operational factors make complete national coverage difficult to attain. Thus, certain groups of schools and students may have to be excluded from the national target population in some situations. For example, it may be that a particular geographical region, educational sub-system, or language group cannot be covered. Such exclusion of schools and students from the target population is referred to either as reduced population coverage or exclusion. Sizeable and structural exclusions can be reported as reduced population coverage (e.g., all schools in particular geographic regions). Smaller exclusions are likely referred to as exclusions, as described below, to the extent they do not exceed acceptable exclusion levels (see Chapter 9 for details on reporting standards).

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

School-Level Exclusions

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

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

Student-Level Exclusions

The international within-school exclusion rules are specified as follows:

- Students with functional disabilities—These are students who have physical disabilities that prevent them from performing in the TIMSS testing situation. Students with functional disabilities who can take the assessment should be included in the testing.
- Students with learning disabilities—These are students considered, in the professional opinion of the school principal or other qualified staff members, to have learning disabilities or who have been tested as such. This includes students who are emotionally or intellectually unable to follow the general instructions of the test. Students should not be excluded solely because of poor academic performance or

normal disciplinary problems. It should be noted that students with dyslexia or other such learning disabilities should be accommodated in the test situation if possible, rather than excluded.

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

NRCs are asked to translate the TIMSS international exclusion standards into the local equivalent because disability criteria vary from country to country. Students should be considered for exclusion 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.

The Sampling Team works with NRCs to keep exclusion rates to a minimum so that national samples accurately represent the national target population. Requirements for exclusion rates include the following:

- The overall number of excluded students must not account for more than 5% 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 student level for each population to be assessed. An example of a completed Sampling Form 2 is presented in Exhibit 3.2.

Exhibit 3.2: Example of Sampling Form 2

Sampling Form 2 — Coverage and Exclusions

See Section 3 of TIMSS 2023 Survey Operations Procedures Unit 1

TIMSS 2023 Participant: *Country X*

1. This Sampling Form refers to: *TIMSS Grade 4 Assessment*

		Number of schools	Number of students
Total enrollment in the target grade:	[a]	*822*	*56,560*

2. School-level exclusions *(if applicable):*

	Description of exclusions	Number of schools	Number of students
1.	*Students taught in language other than English*	*8*	*630*
2.	*Special education schools*	*16*	*325*
3.	*Very small schools (less than 5 students in grade 4)*	*40*	*110*
4.			
5.			
TOTAL:	*(Sum of exclusions - Calculated automatically)* [b]	*64*	*1,065*

		schools	students
Percentage of school-level exclusions: *(Box [b] ÷ Box [a] x 100)*	**[1]**	***7.8%***	***1.9%***

3. Total enrollment after school-level exclusions: *(Box [c] = Box [a] - Box [b])* [c] *758* *55,495*

Totals and percentages calculated automatically

4. Within-school exclusions *(if applicable):*

	Description of exclusions	Number of students
1.	*Students with special education needs (based on TIMSS 2019)*	*640*
2.		
3.		
TOTAL:	*(Sum of exclusions - Calculated automatically)* [d]	*640*

		schools	students
Expected percentage of within-school exclusions: *(Box [d] ÷ Box [c] x 100)*	**[2]**	***0.0%***	***1.2%***

5. **Expected percentage of reduced coverage from exclusions:** *(Box [1] + (1 - Box [1]) X Box [2])* ***7.8%*** ***3.0%***

Totals and percentages calculated automatically

6. Total enrollment in the target grade in previous school years.

Years	Number of schools	Number of students
2020/2021	*856*	*58,451*
2019/2020	*890*	*61,489*

Requirements for Sampling the Target Population

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

Sampling Precision and Sample Size

Because TIMSS is fundamentally a study of student achievement, the precision of estimates of student achievement is of primary importance. To meet the TIMSS standards for sampling precision, national student samples should provide for a standard error no greater than 0.035 standard deviation units for the country's mean achievement. This standard error of 3.5 corresponds to a 95% confidence interval of approximately ±7 score points for the achievement mean, and approximately ±10 score points for the difference of achievement means between successive cycles (e.g., the difference in a country's achievement mean between TIMSS 2019 and TIMSS 2023).[1] Sample estimates of any student-level percentage estimate (e.g., a student background characteristic) should have a confidence interval of ±3.5%. Note that TIMSS standard errors reflect sampling variance and imputation variance (for achievement estimates), but not linking error due to item parameter drift or model error (see more information in Chapter 13).

For most countries, the TIMSS precision requirements are met with a school sample of 150 schools and a student sample designed to yield at least 4,000 assessed 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 student sample size or to provide better estimates 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 TIMSS assessments showed that the sampling precision requirements cannot be met unless a larger school sample is selected.
- Classes within schools are tracked by student performance (more common at eighth grade than at fourth grade). This increases variation between classes and can increase sampling error in student achievement. In this situation, it is advisable to

1 The TIMSS achievement scales were established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS 1995, at each grade level. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution in 1995. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the combined distribution.

sample at least two classrooms per school whenever possible, in addition to sampling more schools.

- A high level of nonresponse 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 nonresponse, it does not compensate for nonresponse bias.

Field Test Sample

Although the TIMSS field test is scheduled in the school year before the year of data collection, the school sample for the field test is usually drawn at the same time and from the same population of schools as the full sample. For other countries, the school sample for the full sample is drawn in the same school year as the data collection when more accurate school data are available for the sampling frame. The field test sample size requirement is based on attaining 200 student responses per item, so the total field test student sample size is a function of the number of achievement booklets being field tested. Typically, the field test sample size for any given assessment cycle consists of 1,000–1,200 students from 25–40 schools.

Participation Rates

To minimize the potential for nonresponse bias, TIMSS aims for 100% participation by sampled schools, classrooms, and students, while recognizing that some degree of nonparticipation 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.

More details on computing participation rates are in a later section of this chapter.

Developing and Implementing the National Sampling Plan

Although NRCs are responsible for developing and implementing national sampling plans, the Sampling Team works closely with them to help ensure that these 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 the Sampling Team.

TIMSS Stratified Two-Stage Cluster Sample Design

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

First Sampling Stage

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

Second Sampling Stage

The second sampling stage consists of selecting one or more intact classes from the target grade of each participating school. The NRC conducts class sampling in each country using the Within-School Sampling Software (WinW3S) developed by IEA Hamburg, which implements requirements for classroom sampling and booklet rotation. Having secured a sampled or replacement school's agreement to participate in the assessment, the NRC requests information about the number of classes and teachers in the school and enters it in the WinW3S database. Classes smaller than a specified minimum size are grouped into pseudo-classes before sampling. The software selects classes with equal probability within schools. All students in each sampled class participate in the assessment. Sampled classes that refuse to participate may not be replaced.

Stratification

Stratification consists of arranging the schools in the target population into groups, or strata, that share common characteristics. Examples of stratification variables used in TIMSS 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); socioeconomic indicators; and school performance on national examinations.

In TIMSS, 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 allocation, 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, the major reason for considering explicit stratification is the disproportionate allocation of the school sample across strata. For example, to produce equally reliable estimates for geographic regions in a country, explicit stratification by region may be used to ensure the same sample size for each region, regardless of the relative population size of the regions.

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

NRCs consult with the Sampling Team to identify the stratification variables to be included in their sampling plans. The school sampling frame is sorted by the stratification variables before sampling schools so that adjacent schools are as similar as possible. Regardless of any other explicit or implicit variables that may be used, the school size is always included as an implicit stratification variable.

To document the stratification variables used in their sampling plans, NRCs complete Sampling Form 3, which lists the variables for explicit and implicit stratification and the number of levels of each stratification variable. An example of a completed Sampling Form 3 is presented in Exhibit 3.3. Details on the explicit and implicit stratification variables used by each country can be found in Chapter 9.

Exhibit 3.3: Example of Sampling Form 3

Sampling Form 3 — **Stratification**

See Section 4 of TIMSS 2023 Survey Operations Procedures Unit 1

TIMSS 2023 Participant :	*Country X*

1. This Sampling Form refers to: *TIMSS Grade 4 Assessment*

Stratification of schools

2. List and describe the variables to be used for stratification in order of importance:
   (Please note that the choice of variables used for explicit or implicit stratification will be discussed during consultations with the TIMSS sampling experts

Stratification Variables			
	Name	**Description**	**# of levels**
1	*School type*	*public, private*	*2*
2	*Socioeconomic status*	*high, medium, low*	*3*
3			
4			
5			
6			

Include additional information if necessary:

3. If applicable, describe any additional requirements for sub-national estimates, either for reporting or analysis purposes (e.g., oversampling of specific groups of the population):

would like to have reliable estimates for students from the private schools

School Sampling Frame

One of the NRC's most important sampling tasks is constructing 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 referring to elements not part of the defined target population.

A suitable school measure of size (MOS) is a critical aspect of the national sampling plan because the size of a school determines its probability of selection. The most appropriate school MOS 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 number of classes in the target grade or total student enrollment in the school may be a suitable substitute.

Sampling Form 4, presented in Exhibit 3.4, 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 MOS to be used for school sampling, and the school year from which the frame was constructed.

The school sampling frame is typically a spreadsheet containing a single entry for each school. This entry includes a unique, randomly generated identification number, the values of the stratification variables for the school, the school MOS, and an indicator for excluded schools (if included in the sampling frame). It is useful if the school entry also includes the number of classes in the target grade for each school because this provides a mechanism for predicting the size of the eventual student sample. This predicted sample size may be compared with the eventual student sample size as a validity check on the sampling implementation. If the number of classes is unavailable, one is derived based on the school's MOS and the average class size.

Exhibit 3.4: Example of Sampling Form 4

Sampling Form 4	Classroom Information and Sampling Frame

See Section 5 of TIMSS 2023 Survey Operations Procedures Unit 1

TIMSS 2023 Participant :	*Country X*

1. This Sampling Form refers to: *TIMSS Grade 4 Assessment*

2. Specify the school measure of size (MOS) to be used.

Click in box and on right arrow to see drop down menu

	Name of the MOS variable in the school frame:
1. Number of students in the target grade (preferred)	*GR4_STD*

If "Other," please describe:

3. Specify the average class size (ACS) for the target grade in your schools. *24*

4. Specify how many classrooms you plan to sample per school.
(Click in box and on right arrow to see drop down menu)

2. More than one classroom in tracked schools

If "Other," please describe:

5. Specify the school year for which enrollment data will be used for the school MOS. *2021/2022*

6. If a frame other than a single-level sampling frame (list of all schools) is to be used, please provide a preliminary description of the information available to construct this frame.

Not applicable

Exhibit 3.5 provides an example of a partial sampling frame for a country conducting TIMSS at the eighth grade. In this example, region and urbanization are used as stratification variables.

Exhibit 3.5: Example of a Partial Sampling Frame

	A	B	C	D	E	F
1	**Random School ID**	**Region**	**Urbanization**	**Grade 8 Students**	**Grade 8 Classes**	**Excluded**
2	Rand1	South	Rural	211	8	0
3	Rand2	North	Rural	176	7	0
4	Rand3	North	Rural	182	7	0
5	Rand4	North	Urban	104	4	0
6	Rand5	North	Rural	228	9	0
7	Rand6	North	Urban	186	7	0
8	Rand7	North	Urban	153	6	0
9	Rand8	North	Urban	169	7	0
10	Rand9	North	Urban	8	1	0
11	Rand10	South	Rural	229	9	0
12	Rand11	South	Rural	164	7	0
13	Rand12	South	Urban	89	4	1
14	Rand13	South	Urban	22	1	0
15	Rand14	North	Urban	65	3	0
16	Rand15	South	Urban	34	1	0
17	Rand16	South	Urban	188	8	0
18	Rand17	South	Rural	6	1	1
19	Rand18	South	Rural	81	3	0
20	Rand19	South	Rural	88	4	0
21	Rand20	South	Rural	54	2	0
22	Rand21	South	Urban	45	2	0
23	Rand22	South	Rural	213	9	0
24	Rand23	South	Rural	290	12	0
25	Rand24	South	Rural	128	5	0
26	Rand25				9	1
27						

Sampling Schools

Once the school sampling frame is structured to meet all international and national requirements, the Sampling Team can draw the school sample. If the sampling frame is explicitly stratified, deciding how the school sample will be allocated among the explicit strata (i.e., the number of schools to be sampled in each stratum) is necessary. When this has been decided, a sample of schools is selected within each explicit stratum using systematic sampling with PPS. The PPS technique means that the larger schools, those with more students, have a higher probability of being sampled than the smaller schools. However, this difference in the selection probabilities of larger and smaller schools is largely offset at the second stage of sampling by selecting a fixed number of classes (usually one or two) with equal probability from the sampled schools.

Classes in large schools with many classes at the target grade have a lower probability of selection than classes in smaller schools that have just one or two classes. A description of the school sampling procedure is provided in Appendix 3A.

Even though the field test is scheduled in the school year before the year of data collection in most countries, the preferred approach in TIMSS is to select both school samples simultaneously. This ensures that 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.[2]

Dealing with Small and Large Schools

The presence of small schools and large schools can be problematic for survey operations and computing sampling weights. Any school whose enrollment of eligible students is less than the national average class size is considered a small school. This leads to some reduction in sample size and fluctuations in sampling weights. Selecting small schools with equal probabilities can reduce these problems. Thus, the measure of size assigned to small schools for sampling becomes the average enrollment in the target grade across all small schools.

Large schools are schools whose enrollment of eligible students is greater than the calculated sampling interval (see Appendix 3A for details). This could result in a large school being selected more than once. The solution is to select all large schools with certainty (selection probability of 1) and compensate by adjusting the sampling interval to maintain the allocated sample sizes.

Replacement Schools

Ideally, all schools sampled for TIMSS should participate in the assessments, and NRCs work hard to achieve this goal. Nevertheless, it is anticipated that a 100% 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 typically has one or two pre-assigned replacement schools, usually the school immediately preceding it on the school sampling frame and the one immediately following it. Replacement schools always belong to the same explicit stratum as the original, but may come from different implicit strata if the school they are replacing is either the first or last school of an implicit stratum.

The main justification for replacement schools in TIMSS 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

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

the school frame is ordered by school size, replacement schools also tend to be similar in size to the school they are designated to replace.

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

Overlap Control in the TIMSS School Sampling Design

The TIMSS school sample design offers considerable flexibility in allowing countries to control the overlap between grades or with other national or international assessments. Where fourth- and eighth-grade students attend the same school, some countries find it more efficient to administer TIMSS at the same school for both grades and aim to maximize overlap. In other cases, countries try to ensure that assessments are spread across schools and therefore prefer that TIMSS at the fourth and eighth grades are not administered at the same school and that TIMSS sampling avoid, when possible, selecting schools that have recently administered other national and international assessments. To provide flexibility in meeting these requests, the Sampling Team implements modified sampling procedures, the details of which are described in Appendix 3B. Any such modifications implemented for a country are documented in Chapter 9.

Sampling Classes

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

Because small classes tend to increase the risk of less-reliable survey estimates from weight fluctuations and can lead to reduced overall student sample size, it is necessary to minimize sampling small classes. Considering the size distribution of classes and the average class size, a minimum class size (MCS) is specified for each country. It is typically set as half the average class size. Before sampling classes in a school, any class smaller than the MCS is combined with another class to form a "pseudo-class" for sampling purposes. When a pseudo-class is sampled, all component classes are selected.

Computing Sampling Weights

As described earlier, national student samples in TIMSS are designed to accurately represent the target populations within a specified sampling error margin. 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, where schools are sampled with probability proportional to school size and classes with equal probability within schools, provides student samples with roughly equal selection probabilities. In practice, disproportionate sampling across explicit strata, variations in the number of classes selected, and differential patterns of nonresponse can result in varying selection probabilities, requiring a unique sampling weight for the students in the TIMSS samples.

The student sampling weight in TIMSS consists 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 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 MOS 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.

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

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

where n_s is the number of originally sampled schools that participated; n_{r1} and n_{r2} the number of first and second replacement schools, respectively, that participated; and n_{nr} is the number of schools that did not participate. Sampled schools that are found to be ineligible[3] are not included in the calculation of this adjustment.

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

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

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

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

Class Weighting Component

The class weighting component reflects the class-within-school selection probability. After a school has been sampled and has agreed to participate in TIMSS, one or more 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 participants, c^i takes the values 1 or 2. In some instances, $c^i = C^i$.

A class-level nonparticipation adjustment is applied to compensate for classes that do not participate or where the student participation rate is below 50%. Class nonparticipation adjustments are applied at the explicit stratum level rather than at the school level to minimize the risk of bias. Thus, the class nonparticipation adjustment is the same for all schools in a given explicit stratum. The adjustment is calculated as follows:

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

where c^i is the number of sampled classes in the i^{th} school, as defined earlier, and δ_i 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 probability of student-within-class selection. The basic student weight is the inverse of the probability of a student in a sampled class being selected.

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

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

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

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 and $n_{bs}^{i,j}$ is the number of students in the class not selected.

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 in the j^{th} class of the i^{th} school and $s_{nr}^{i,j}$ is the number of students sampled in this class who were selected but did not participate in the assessment. For intact classes, the sum of $s_{rs}^{i,j}$ and $s_{nr}^{i,j}$ is the total number of students listed in the class, not counting excluded students or students no longer in the class since the class list was published.

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 is drawn from the students in the class.

Overall Student Sampling Weight

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

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

Overall student sampling weights are only attributed to participating students, with nonparticipating students weighted at 0 and excluded from the public-use international databases. All results reported in the TIMSS international reports are weighted by the overall student sampling weight, known as TOTWGT in the TIMSS international database.

Computing Participation Rates

Because nonparticipation can result in sample bias and misleading results, it is important that the schools, classes, and students that are sampled in TIMSS take part in the assessments. To show the level of sampling participation in each country, TIMSS 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, classes, and students, whereas weighted participation rates are the ultimate measures of sampling participation.

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

Unweighted School Participation Rate

The unweighted school participation rate is the ratio of the number of participating schools to the number of originally sampled schools, excluding any sampled schools found to be ineligible. A school is considered a "participating school" if at least one of its sampled classes has a student participation rate of at least 50%. 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:

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

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 Rate

The unweighted student participation rate is the ratio of the number of selected students that participated in TIMSS to the total number of selected students that should have been assessed in the participating schools and classes. Classes where less than 50% of the students participate are considered not participating, so students in such classes are also considered 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 Rate

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

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

R_{unw}^{ov-r} = unweighted overall participation rate, including 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 Rate

The weighted school participation rate is the ratio of two estimates of the size of the target student population. The numerator is derived from the MOS of those sampled schools that participated in TIMSS, 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

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

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

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

Weighted Class Participation Rate

The weighted class participation rate is computed as follows:

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

where both the numerator and denominator are summations over all responding students, 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. 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 replaced.

Weighted Student Participation Rate

The weighted student participation rate is computed as follows:

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

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

Overall Weighted Participation Rate

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

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

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

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

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

Using these procedures, weighted school, class, student, and overall participation rates are computed for each TIMSS participating country.

References

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Appendix 3A: Sampling Schools

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

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

First Step: Compute the Sampling Interval

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

- **59,614 ÷ 50 = 1,192.2800**

Second Step: Generate a Random Start

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

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

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

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

Fourth Step: Identify Replacement Schools

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

Example of PPS Systematic Sampling—Schools

Sampling Parameters	
Total Number of Schools:	2,119
Total Measure of Size:	59,614
School Sample Size:	50
Sampling Interval:	1,192.2800
Random Start:	653.4887

First Step

Compute the Sampling Interval:

59,6914 ÷ 50 = 1,192.2800

Second Step

Generate a random start:

0.5481 × 1,192.2800 = 653.4887

Third Step (repeat until complete)

Compute the next selection numbers:

653.4887 + 1,192.2800 = 1,845.7687

1,845.7687 + 1,192.2800 = 3,038.0487

Fourth Step

Identify Replacement Schools

(R1, R2)

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

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

TIMSS provides optional modifications to its sampling design for countries that want to control overlap between schools sampled by TIMSS at the fourth and eighth grades and between schools sampled for TIMSS and schools sampled for other national or international assessments.

To provide options for countries in designing their school samples, the TIMSS Sampling Team implements two special sampling procedures. Method A is applied when data collection occurs simultaneously for two or more populations (as is the case in TIMSS at fourth grade and eighth grade) and the country wants to control the overlap between the schools. Method B is used primarily to ensure that the TIMSS samples avoid schools sampled for other studies, and also used when Method A is not appropriate.

Sampling Method A: Sampling Modifications for Simultaneous Data Collection

This procedure stratifies the school population according to whether schools contain students from both populations to be sampled (fourth and eighth grades, for example) or students from one population only (fourth grade only or eighth grade only) to control sample overlap. Each school is assigned a measure of size (MOS) based on the number of students in the two populations combined (i.e., fourth grade and eighth grade combined). Schools are sampled according to the sampling design described in this chapter. When selecting schools from strata comprising students from both populations, a country can choose to maximize or minimize the number of schools to be sampled at each grade level.

The example below shows a hypothetical country participating in TIMSS at both grades. For administrative efficiency reasons, the country wants to maximize the overlap between the fourth- and eighth-grade school samples. The 8,805 schools from the combined school frames (fourth and eighth grades) are first split in three strata, and then a school sample of 164 are drawn as shown in the example.

Example of Method A—Allocation of School Samples in a Country Participating at Two Grade Levels

Overlap Strata	Total Sampled Schools	Allocation	
		To TIMSS Grade 4	To TIMSS Grade 8
Grade 4 only	14	14	0
Grade 8 only	14	0	14
Grade 4 & Grade 8	136	136	136
Total	**164**	**150**	**150**

Choosing as many schools as possible from the Grade 4 & Grade 8 stratum results in a sample of 150 schools (136+14) for each grade level, from a total of 164 sampled schools. In this case, both studies are administered in the 136 schools selected from the Grade 4 & Grade 8 stratum.

This sampling technique is most often used for TIMSS countries that have schools with students in both fourth- and eighth-grade populations, where there is a strong correlation between the MOS at both grades across these schools, and when school samples can be drawn at the same time.

Sampling Method B: Sampling Modifications for Sequential Data Collection

Method B is used to minimize or maximize overlap with another study, such as a national study that also samples schools, and is also used when Method A is not appropriate (e.g., low correlation between MOS for fourth grade and eighth grade, samples not drawn simultaneously). In Method B, schools are sampled using a technique described in Chowdhury et al. (2000). As explained by the authors, the method can be used to either minimize or maximize overlap amongst several samples. This method is illustrated below with an example where the aim is to minimize the overlap between a current sample of schools S_2 and a previously selected school sample S_1. (For a complete description of the method, readers are referred to the original paper).

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

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

$$P_i(S_2) = P_i(S_2|S_1)\cdot P_i(S_1) + P_i(S_2|\overline{S}_1)\cdot P_i(\overline{S}_1) \tag{3.1}$$

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

Note that the first term after the equal sign in equation (3.1) is related to cases where the school response load is 1, while the last term is related to cases where the school response load is 0. Therefore, minimizing the sample overlap is equivalent to zeroing the first term. In such case, equation (3.1) becomes:

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

and consequently,

$$P_i(S_2|\overline{S}_1) = P_i(S_2)/P_i(\overline{S}_1)$$

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

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

However, equation (3.1) no longer holds if expression $P_i(S_2)/P_i(\overline{S}_1)$ is greater than 1. This can be avoided by setting 1 as an upper bound. We now have the following expression:

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

and consequently

$$\frac{P_i(S_2) - P_i(\overline{S}_1)}{P_i(S_1)} = P_i(S_2|S_1)$$

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

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

Note that maximizing rather than minimizing the overlap between two studies can be done by simply zeroing the last term of equation (3.1) rather than zeroing the first term and following the same logic to derive the conditional probabilities. The Chowdhury et al. (2000) method can be generalized to more than two samples, as described in their paper.

Further details about the implementation of this method in TIMSS can be found in Chapter 9.