CHAPTER 9

Creating the PIRLS 2016 International Database

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This chapter describes the procedures implemented by IEA Hamburg for verifying the PIRLS 2016 data and creating the PIRLS 2016 International Database (IDB).

Preparing the PIRLS 2016 International Database (IDB) and ensuring its integrity was a complex endeavor requiring extensive collaboration between IEA Hamburg, the TIMSS & PIRLS International Study Center, Statistics Canada, and the national centers of participating countries. Once the countries had created their data files and submitted them to IEA Hamburg, an exhaustive process of verification and editing known as "data cleaning" began.

Data cleaning is the process of checking data for inconsistencies and formatting the data to create a standardized output. The overriding concerns of the data cleaning process were to ensure:

- All information in the database conformed to the internationally defined data structure

- The content of all codebooks and documentation appropriately reflected national adaptations to questionnaires

- All variables used for international comparisons were in fact comparable across countries (after harmonization, where necessary)

- All institutions involved in this process applied quality control measures throughout in order to assure the quality and accuracy of the PIRLS 2016 data

IEA Hamburg was responsible for checking the data files from each country, applying standardized data cleaning rules to verify the accuracy and consistency of the data and documenting any deviations from the international file structure. Data files were created at each country's national center and reviewed prior to submission to IEA Hamburg. The National Research Coordinators (NRCs) from each country collaborated with IEA Hamburg to resolve any queries which emerged during the data cleaning process, and the NRCs checked interim versions of the national/benchmarking participant database(s) produced by IEA Hamburg.

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The TIMSS & PIRLS International Study Center provided the NRCs with univariate data almanacs containing summary statistics on each variable so that the national centers could evaluate their data from an international perspective. The TIMSS & PIRLS International Study Center also scaled the achievement and background data, as documented in Chapter 12: Scaling the PIRLS 2016 Achievement Data and in Chapter 14: Creating and Interpreting the PIRLS 2016 Context Questionnaire Scales, and produced achievement scores (plausible values) and scores on the background scales. Using the Windows® Within-school Sampling Software (WinW3S)[1] database and processed response data provided by IEA Hamburg, Statistics Canada in collaboration with IEA Hamburg calculated the sampling weights, population coverage, and school and student participation rates—as documented in Chapter 3 and Chapter 5.

Data Sources

Data Entry and Verification of Paper Booklets and Questionnaires

Each national center was responsible for inputting the information collected in paper-based test booklets and questionnaires into computer data files using the IEA Data Management Expert (DME) software. The DME is a software system developed by IEA Hamburg that facilitates data entry and includes validation checks to identify inconsistencies. As a general principle, national centers were instructed to enter data for any booklet or questionnaire that contained at least one valid response, discarding unused or empty instruments.

National centers entered responses from the paper instruments into data files using a predefined international codebook. The codebook defines the structure of the data to be entered and contains information about the variable names, lengths, labels, and missing codes, as well as variable ranges for continuous measures or counts and valid values for nominal or ordinal questions.

As documented in Chapter 7: Translation and Layout Verification for PIRLS 2016, countries participating in PIRLS are expected to make national adaptations to certain questions in the international source versions of the context questionnaires (e.g., the questions about parents' education must be adapted to the national context). Countries making such adaptations were required to adapt the codebook structure to reflect the adaptations made to the national questionnaire versions before beginning the data entry process.

To ensure consistency across participating countries, the basic rule for data entry in the DME required national staff to enter data "as is" without any interpretation, correction, truncation, imputation, or cleaning.

The guiding principles for data entry included the following:

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1   WinW3S is software developed by IEA Hamburg that stores participation information at school, teacher, class, and student levels in a relational database while maintaining a hierarchical ID system. The software allows users to perform all necessary within-school sampling according to the PIRLS standards, and also provides some data validation in and across these levels.

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- Responses to closed response items entered as "1" if the first option was used, "2" if the second option is marked, and so on

- Responses to open response questions, for example number of students in the PIRLS class, entered "as is" even if the value is outside the originally expected range

- Responses to filter questions and filter-dependent questions entered exactly as filled in by the respondent, even if the information provided is logically inconsistent

- Non-response, ambiguous responses, responses given outside of the expected format, or conflicting responses (e.g., selection of two options in a multiple-choice question), coded as "omitted or invalid"

As each respondent ID number was entered, it was checked by the DME software for alignment with a five-digit checksum generated by WinW3S. A mistype in either the ID or the checksum resulted in an error message prompting the data entry person to check the entered values. The data verification module of DME also checked for a range of other issues such as inconsistencies in identification codes and out-of-range or otherwise invalid codes. When such issues were flagged by the software, the individuals entering the data were prompted to resolve the inconsistency or confirm that an issue existed before resuming data entry.

Double Data Entry

To check data entry reliability in participating countries, national centers were required to enter a 5 percent sample of each survey instrument (achievement booklet or questionnaire) twice by two different data entry persons (punchers). IEA Hamburg recommended that countries begin the double data entry process as early as possible during the data capture period in order to identify possible systematic misunderstandings or mishandlings of data entry rules and to initiate appropriate remedial actions—for example, retraining national center staff. Those entering the data were required to resolve discrepancies between the first and second data entries by consulting the original questionnaire and applying the international rules in a uniform way.

Although it was desirable that each and every discrepancy be resolved before submission of the complete dataset, the acceptable level of disagreement between the originally entered and double entered data was established at 1 percent or less for questionnaire data and at 0.1 percent or less level for achievement data. Values above this level required a complete re-entry of data.

The level of disagreement between the originally entered data and double entered data was evaluated by IEA Hamburg, and it was found that in general the margin of error observed for processed data was well below the required threshold.

Data from ePIRLS Administration

The ePIRLS assessment was designed to run on PCs using one of two methods: USB or server delivery. In the simpler USB delivery, a USB stick pre-loaded with the ePIRLS software was inserted into a USB port on a student's computer. The Test Administrator located and ran the program and

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then entered the ID and checksum (i.e., password) from the Student Tracking Form to begin the assessment. For the server delivery, a PC serving as a local server and having the ePIRLS software installed was connected to the school's Local Area Network (LAN), and the individual student PCs accessed the assessment over the LAN using a Firefox browser. Similar to the USB method, IDs and checksums from the Student Tracking Form were used to identify the student and begin the assessment, and checksums also contained information on which task is assigned to students.

For both delivery methods, the student response data were stored in a SQL-Compact database, the contents of which could be uploaded to the IEA Hamburg server immediately following the assessment, or later off-site. Following data upload, student responses to constructed response items were sent to the Online Scoring System, which almost immediately made student responses available to be allocated to scorers. Scoring took place directly on the IEA Hamburg server— allowing IEA Hamburg to monitor, in real time, the progress of scoring within countries.

Also available online to national centers was an upload monitor listing all the student records that had been uploaded to the IEA Hamburg server. In the rare cases that duplicate IDs were detected, the IDs were flagged and national centers indicated which record to keep. The data monitor also allows a list of IDs to be downloaded so that they can be used to update data availability status in WinW3S.

Data from Online Questionnaire Administration

As documented in [Chapter 6: Survey Operations Procedures](#) in PIRLS 2016, national centers had the option of administering the school, teacher, and home questionnaires online instead of, or in addition to, using paper-based questionnaires. Students participating in ePIRLS also completed a brief questionnaire following the assessment through the ePIRLS software. To ensure confidentiality, national centers provided every respondent with a letter containing individual login information along with information on how to access the online questionnaire. This login information corresponded to the ID and checksum provided from WinW3S, meaning that the identity validation step occurring at the national centers for paper-based questionnaires occurred when the respondents' logged in to the survey.

Online administration of questionnaires had a number of advantages. Because responses were collected in digital format and stored directly on the IEA Hamburg server, there was no need for data entry, reducing the workload for national centers. Also, the online system does not allow for inconsistent response patterns, meaning that the data collected had fewer inconsistencies when compared with data collected through the paper-based questionnaires. For example, if the directions ask the respondent to "Check one circle for each line," the system does not allow the respondent to check more than one response category on each line.

The PIRLS 2016 online questionnaires also include skip logic, which minimized response burden and improved data consistency. The PIRLS questionnaires have a number of questions that filter out respondents—meaning the subsequent questions are not applicable given the response

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to the filter question. For example, Question 9 of the school questionnaire reads: "Does your school have a school library? If yes, go to #9a, and if No, go to #10." If a respondent chooses "No," the online survey skips directly to Question 10, omitting Questions 9a and 9b. Not only does the skip logic save the respondents' time, it also results in fewer inconsistencies in the data received by IEA Hamburg.

Data Verification at the National Centers

Before sending the data to IEA Hamburg for further processing, national centers carried out mandatory validation and verification steps on all entered data and undertook corrections as necessary.

While the questionnaire data were being entered, the data manager or other staff at each national center used the information from the Tracking Forms to verify the completeness of the materials. Student participation information (e.g., whether a student participated in the assessment or was absent) was entered or imported into WinW3S.

The validation process was supported by an option in WinW3S to generate an inconsistency report. This report listed all of the types of discrepancies between variables recorded during the within-school sampling and test administration processes and made it possible to cross-check these data against data entered in the DME, the database for online respondents, and the uploaded student data on the central international server. When inconsistencies were identified, data managers were instructed to resolve the issue before final data submission to IEA Hamburg. If inconsistencies remained or the national center could not solve them, IEA Hamburg asked the center to provide documentation on these problems.

Upon submitting the validated data to IEA Hamburg, NRCs also provided extensive documentation including hard copies or electronic scans of all original Student and Teacher Tracking Forms, Student Listing Forms, and when applicable, a report on procedural activities collected as part of the online Survey Activities Questionnaire (see Chapter 6).

Cleaning the International and National Databases

Overview

To ensure the integrity of the international database, a uniform data cleaning process was followed, involving regular consultation between IEA Hamburg and the NRCs. After each country had submitted its data, codebooks, and documentation, IEA Hamburg, in collaboration with the NRCs, conducted a four-step cleaning procedure on the submitted data and documentation:

1. A structural check

2. A check of the identification (ID) variables

3. Linkage cleaning

4. Background cleaning

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Data cleaning was an iterative process, with numerous iterations of the four-step cleaning procedure being implemented for each national data set. This repetition ensured that all data were properly cleaned and that any new errors that could have been introduced during the data cleaning were rectified. The cleaning process was repeated as many times as necessary until all data were made consistent and comparable. Any inconsistencies detected during the cleaning process were resolved in collaboration with national centers, and all corrections made during the cleaning process were documented in a cleaning report, produced for each country.
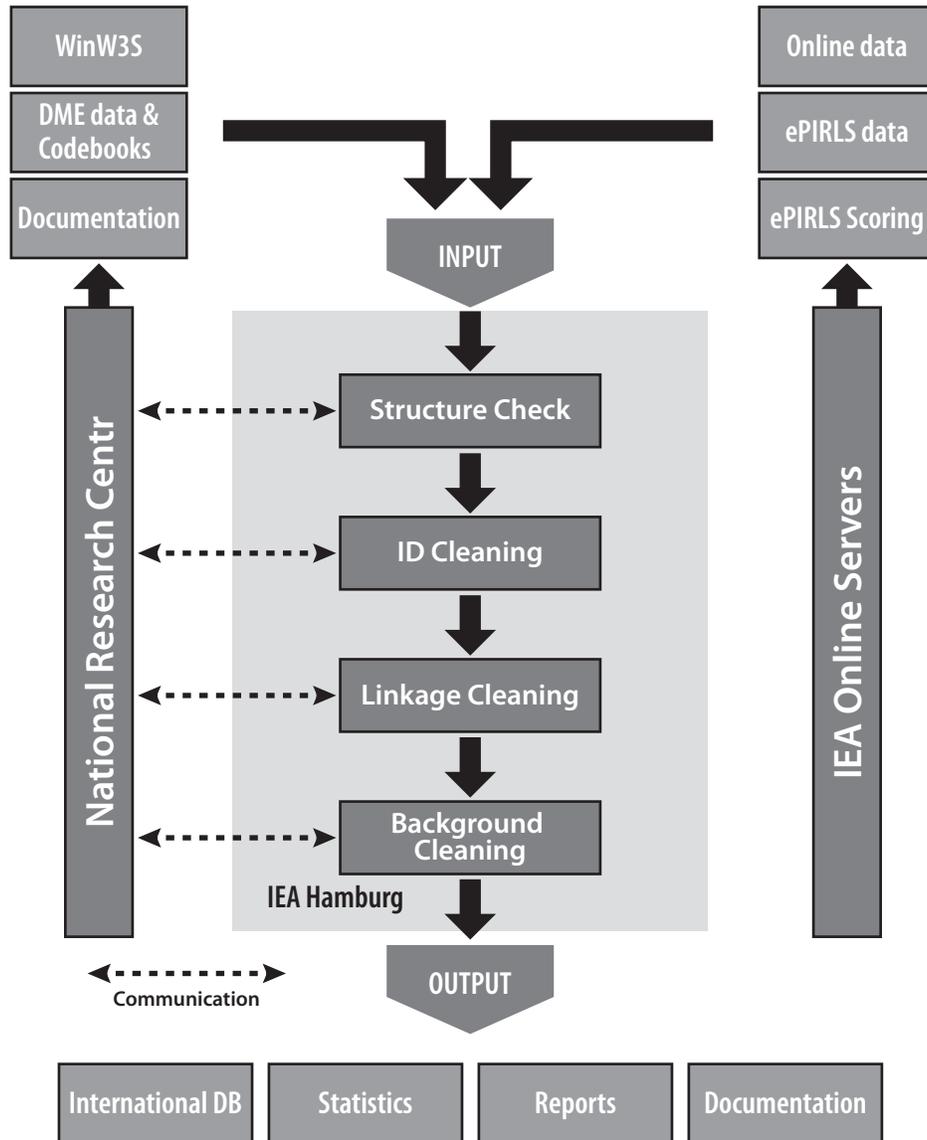
After the final cleaning iteration, each country's data were sent to Statistics Canada for the calculation of sampling weights, and then the data, including sampling weights, were sent to the TIMSS & PIRLS International Study Center so that scaling could be performed. The NRCs were provided with interim data products to review at two different points in the process.

Preparing National Data Files for Analysis

The main objectives of the data cleaning process were to ensure that the data adhered to international formats, that school, teacher, and student information could be linked across different survey files, and that the data reflected the information collected within each country in an accurate and consistent manner.

As illustrated in Exhibit 9.1, the program-based data cleaning consisted of a set of activities explained in the following subsections. IEA Hamburg carried out all of these activities in close communication with the national centers.

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Exhibit 9.1: Overview of Data Processing at IEA Hamburg

Structural Check

For each country, data cleaning began with a review of data file structures and data documentation, including a review of national adaptation comments, Student Listing Forms, Student Tracking Forms, Teacher Tracking Forms, and the Survey Activities Questionnaire.

After the review, IEA Hamburg merged the tracking information and sampling information captured in the WinW3S database with the student-level databases containing the corresponding student instrument data, and, if applicable, ePIRLS data. For countries administering questionnaires through online and paper modes, IEA Hamburg merged the questionnaire data across modes of administration. At this stage, data from the different sources were transformed and imported into one SQL database so that this information would be available during all further data processing stages.

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The first checks identified differences between the international and the national file structures. Some countries made adaptations (such as adding national variables or omitting or modifying international variables) to their questionnaires. The extent and nature of these changes differed across countries: some countries administered the questionnaires without any modifications (apart from translations and necessary adaptations relating to cultural or language-specific terms), whereas other countries inserted response categories within existing international variables or added national variables.

To keep track of adaptations, staff at the TIMSS & PIRLS International Study Center asked the national centers to complete National Adaptations Forms. In their adaptations, countries sometimes modified the structure and values of the international codebooks, and in these cases IEA Hamburg recoded the national data files to ensure that the resulting data remained comparable across countries. The national adaptation process is described in Chapter 7 and details about country-specific adaptations to the international instruments can be found in Supplement 2 of the *PIRLS 2016 User Guide for the International Database*.

IEA Hamburg then discarded variables created purely for verification purposes during data entry and made provisions for adding new variables necessary for analysis and reporting, including reporting variables, derived variables, sampling weights, and scale scores.

Once IEA staff had ensured that each data file matched the international format, they applied a series of standard data cleaning rules for further processing. Processing during this step employed software developed by IEA Hamburg that could identify and correct inconsistencies in the data. Each potential problem flagged at this stage was identified by a unique problem number, and then described and recorded in a database. The action taken by the cleaning program or IEA staff with respect to each problem was also recorded.

IEA Hamburg referred problems that could not be rectified automatically through the program to the responsible NRC so that national center staff could check the original data collection instruments and Tracking Forms to trace the source of the error. Wherever possible, staff at IEA Hamburg suggested a remedy and asked the national centers to either accept it or propose an alternative. If a national center could not solve the issue through verification of the instruments or forms, IEA Hamburg applied a general cleaning rule to the files to rectify the error. When all automatic updates had been applied, IEA staff used SQL recoding scripts to directly apply any remaining corrections to the data files.

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Checking Identification Variables

Each record in a data file needs to have a unique identification number. The existence of records with duplicate ID numbers in a file implies an error of some kind. Some countries administered the school, teacher, and home questionnaire online in addition to on paper. This yields the possibility that a respondent could complete both the paper and the online versions of the questionnaire. Similarly, it was possible for an ePIRLS login to be used (and uploaded) twice. If two records in a PIRLS 2016 database shared the same ID number and contained exactly the same data, IEA Hamburg deleted one of the records and kept the other one in the database. In the rare case that both records contained different data and IEA staff found it impossible to identify which record contained the "true data," national centers were asked which record to keep.

Although the ID cleaning covered all data from all instruments, it focused mainly on the student files. In addition to checking the unique student ID numbers, it was crucial to check variables pertaining to student participation and exclusion status, as well as students' birth dates and dates of testing in order to calculate student age at the time of testing. The Student Tracking Forms provided an important tool for resolving anomalies in the database.

As mentioned previously, IEA Hamburg conducted all cleaning procedures in close cooperation with the national centers. After national center staff had cleaned the identification variables, they passed the clean databases with information about student participation and exclusions on to Statistics Canada, which used this information to calculate student participation rates, exclusion rates, and student sampling weights.

Cleaning Linkages

As data on students, parents, teachers, and schools appeared in a number of different data files, a process of linkage cleaning was implemented to ensure that the data files would correctly link together. The linking of the data files followed a hierarchical system of identification codes that included school, class, and student components. These codes linked the students with their class and/or school membership. Further information on linkage codes can be found in Chapter 6: Survey Operations Procedures in PIRLS 2016.

Linkage cleaning consisted of a number of checks to verify that student entries matched across achievement files, student background files, scoring reliability files, and home background files. In addition, at this stage, checks were conducted to ensure that teacher and student records linked correctly to the appropriate schools. The Student Tracking Forms, Teacher Tracking Forms, and Student Listing Forms were crucial in resolving any anomalies. IEA Hamburg also liaised with NRCs about any problematic cases, and the national centers were provided with standardized reports listing all inconsistencies identified within the data.

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Background Cleaning

The amount of inconsistent and implausible responses in questionnaire data files varied considerably across countries. IEA Hamburg determined the treatment of inconsistent responses on a question-by-question basis, using all available documentation to make an informed decision. IEA Hamburg staff also checked all questionnaire data for consistency across the responses given. For example, Question 1 in the school questionnaire asked for the total school enrollment in all grades, and Question 2 asked for the enrollment in the target grade only. Logically, the number given as a response to Question 2 could not exceed the number provided by school principals in Question 1. Similarly, it is not possible that the amount of years a teacher has been teaching altogether (Question 1 in the teacher questionnaire) exceeds his/her age (Question 3 in the teacher questionnaire). IEA Hamburg flagged inconsistencies of this kind and then asked the national centers to review these issues. IEA staff recoded those cases that could not be corrected as "invalid."

Filter questions, which appeared in some questionnaires, directed respondents to a particular subquestion. IEA Hamburg applied the following cleaning rule to these filter questions and the dependent questions that followed: If a respondent answered "No" to Question 9 in the school questionnaire "Does your school have a school library?," IEA Hamburg recoded any responses to the dependent questions as "logically not applicable." Also, following the same example, if the filter question was omitted but at least one valid response was found in the dependent questions then IEA Hamburg recoded the filter question to "Yes." This of course is only possible for dichotomous filter questions (e.g., with response options such "Yes/No").

IEA Hamburg also applied what are known as split variable checks to questions where the answer was coded into several variables. For example, Question 5 in the student questionnaire asked students: "Do you have any of these things at your home?" Student responses were captured in a set of eight variables, each one coded as "Yes" if the corresponding "Yes" option was filled in and "No" if the "No" option was filled in. Occasionally, students checked the "Yes" boxes for some items but left the boxes for the remaining items unchecked. Because, in these cases, it was clear that the unchecked boxes actually meant "No," these responses were recoded accordingly.

In addition, student reports to items on gender and age in the student questionnaire were checked against the tracking information provided by the School Coordinator or Test Administrator during the within-school sampling and test/questionnaire administration process. When information on gender or birth year and month was missing in the student questionnaire but the student participated, this information, when available, was copied over from the tracking data to the questionnaire. If discrepancies were found between existing tracking and questionnaire gender and age data, IEA Hamburg queried the case with the national center, and the national center investigated which source of information was correct. If unresolved, tracking data was trusted over questionnaire data.

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Handling of Missing Data

Two types of entries were possible during the PIRLS 2016 data capture: valid data values and missing data values. Missing data can be assigned a value of "omitted/invalid" or "not administered" during data capture. IEA Hamburg applied additional missing codes to the data to facilitate further analyses. This process led to four distinct types of missing data in the international database:

- Omitted or invalid: The respondent had a chance to answer the question but did not do so, leaving the corresponding item or question blank. This code was also used if the response was uninterpretable or out-of-range.

- Not administered: This signified that the item or question was not administered to the respondent, which meant that the respondent could not read and answer the question. The not administered missing code was used for those student test items that were not in the set of assessment blocks administered to a student either deliberately (due to the rotation of assessment blocks) or in rare cases due to technical failure or incorrect translations. This missing code was also used for those records that were included in the international database but did not contain a single response to one of the assigned questionnaires. For example, this situation applied to home questionnaire data for students who participated in the student test but the parent/guardian did not answer the home questionnaire. In addition, the not administered code was used for individual questionnaire items that a national center decided not to include in the country-specific version of the questionnaire.

- Logically not applicable: The respondent answered a preceding filter question in a way that made the following dependent questions not relevant to him or her.

- Not reached: This applied only to the individual items of the student achievement test and indicated those items that students did not attempt due to a lack of time. "Not reached" codes were derived as follows: First, the last answer given by a student in a session is identified. This could be either a valid or invalid response to an item. The first omitted response after this last answer is coded as "omitted," but all following responses to these items in the session are then coded as "not reached." For example, the response pattern "1 9 4 2 9 9 9 9 9" (where "9" represents "omitted") is recoded to "1 9 4 2 9 R R R R R" (where "R" represents "not reached").

Data Cleaning Quality Control

Because PIRLS 2016 was a large and highly complex study with very high standards for data quality, maintaining these standards required an extensive set of interrelated data checking and data cleaning procedures. To ensure that all procedures were conducted in the correct sequence, that no special requirements were overlooked, and that the cleaning process was implemented independently of the persons in charge, the data quality control process included the following steps:

- Thorough testing of all data cleaning programs: Before applying the programs to real datasets, IEA Hamburg applied them to simulation datasets containing all possible problems and inconsistencies

- Registering all incoming data and documents in a specific database: IEA Hamburg recorded the date of arrival as well as specific issues requiring attention

- Carrying out data cleaning according to strict rules: Deviations from the cleaning sequence were not possible, and the scope for involuntary changes to the cleaning procedures was minimal

- Documenting all systematic data recodings that applied to all countries: IEA Hamburg recorded all changes to data in the comprehensive cleaning documentation provided to national centers

- Logging every "manual" correction to a country's data files in a recoding script: Logging these changes, which occurred only occasionally, allowed IEA staff to undo changes or to redo the whole manual cleaning process at any later stage of the data cleaning process

- Repeating, on completion of data cleaning for a country, all cleaning steps from the beginning: This step allowed IEA Hamburg to detect any problems that might have been inadvertently introduced during the data cleaning process

- Working closely with national centers at various steps of the cleaning process: IEA Hamburg provided national centers with the processed data files and accompanying documentation so that center staff could thoroughly review and correct any identified inconsistencies

IEA Hamburg compared national adaptations recorded in the documentation for the national datasets with the structure of the submitted national data files. IEA staff then recorded any identified deviations from the international data structure in the national adaptation database and for the supplementary materials provided with the *PIRLS 2016 User Guide for the International Database*. Whenever possible, IEA Hamburg recoded national deviations to ensure consistency with the international data structure.

Interim Data Products

Before the PIRLS 2016 International Databases were finalized, two major interim versions of the data files were sent to each country—each country receiving only its own data. The first version was sent as soon as the data could be considered "clean" as regards identification codes and linkage issues. Documentation, with a list of the cleaning checks and corrections made in the data, was included to enable the NRC to review the cleaning process before the 7th NRC meeting in Agadir, Morocco in December 2016. A second version of the data files was sent to countries when the

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weights and international achievement scores were available and had been merged with the data files. This version, sent to countries in advance of the 8th NRC meeting in Riga, Latvia in June 2017, contained only records that satisfied the sampling standards, and allowed the NRCs to replicate the results presented in the international reports.

Interim data products were accompanied by detailed data processing and national adaptation documentation, codebooks, and summary statistics. The summary statistics, preliminary versions of the PIRLS 2016 Almanacs, were created by the TIMSS & PIRLS International Study Center and included weighted univariate statistics for all questionnaire variables for each country. For categorical variables, representing the majority of variables, the percentages of respondents choosing each of the response options were displayed. For continuous numeric variables, various descriptive statistics were reported, including the minimum, maximum, mean, standard deviation, median, mode, and percentiles. For both types of variables, the percentages of missing data were reported. Additionally, for the achievement items, the TIMSS & PIRLS International Study Center provided item analysis and reliability statistics listing information regarding the number of valid cases, percentages, percent correct, Rasch item difficulty, scoring reliability, and so forth. These statistics were used for a more in-depth review of the data at the international and national levels in terms of plausibility, unexpected response patterns, etc. More information on reviewing item statistics is available in Chapter 10.

Final Product – the PIRLS 2016 International Databases

The data cleaning effort implemented at IEA Hamburg ensured that the PIRLS 2016 international databases contained high-quality data. More specifically, the process ensured that:

- Information coded in each variable was internationally comparable

- National adaptations were reflected appropriately in all variables

- All entries in the database could be successfully linked within and across levels

- Sampling weights and student achievement scores were available for international comparisons

Supplements to the *PIRLS 2016 User Guide for the International Database* document all national adaptations made to questionnaires by individual countries and how they were handled in the data. The meaning of country-specific items also can be found in this supplement, as well as recoding requirements by the TIMSS & PIRLS International Study Center.

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