IEA International Computer and Information Literacy Study 2023

USER GUIDE FOR THE INTERNATIONAL DATABASE

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Editors

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User Guide

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Information Literacy Study 2023

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Researching education, improving learning

The International Association for the Evaluation of Educational Achievement (IEA) is an independent, international cooperative of national research institutions and governmental research agencies. It conducts large-scale comparative studies of educational achievement and other aspects of education, with the aim of gaining in-depth understanding of the effects of policies and practices within and across systems of education.

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Introduction

Tim Daniel and Sebastian Meyer

Overview

The IEA International Computer and Information Literacy Study 2023 (ICILS 2023) investigated students' capacities to use information and communications technology (ICT) productively for a range of different purposes, in ways that go beyond a basic use of ICT. ICILS 2023 builds on the work of previous ICILS cycles conducted in 2013 and 2018, by monitoring the development of these essential digital literacy-related capabilities over time, and by contributing to our understanding of the contexts in which students develop these capabilities, and how these contexts relate to student learning and achievement. With each cycle of ICILS, the study evolves to remain current in an environment of rapidly developing digital technologies.

ICILS 2023 provides, across relevant countries, the opportunity to report on trends in student Computer and Information Literacy (CIL) achievement across three assessment cycles since 2013, and on trends in Computational Thinking (CT) achievement across two assessment cycles since 2018.

In addition to measuring variations in CIL and CT among and within countries, ICILS 2023 reports on the relationships between CIL and CT, as well as the relationships between those constructs and students' background characteristics, their access to, and attitudes toward ICT, and their use of ICT both within school, and outside of school.

The ICILS 2023 international database provides researchers, analysts, and other users with access to the data collected and analyzed during the ICILS 2023 project, facilitating and encouraging secondary analysis. ICILS 2023 collected data from 132,998 grade 8 (or equivalent) students in 5,299 schools across 34 countries and one benchmarking participant. These student data were augmented by data from 60,835 teachers in those schools, and by contextual data collected from school ICT coordinators, principals, and national research centers. Twenty-four countries, and one benchmarking participant also participated in the optional CT assessment.

About the user guide

This user guide describes the content and format of the data in the ICILS 2023 international database and presents example analyses with the data. Following this introductory chapter, the user guide includes the following chapters:

Chapter 2 serves as a reference for details about the structure and contents of the ICILS 2023 international database, including detailed descriptions of the various data files, conventions for naming data files and variables, and descriptions of all the supporting documentation provided with the international database.

Chapter 3 introduces the use of weighting and variance estimation variables for analyzing the ICILS 2023 data. It also provides guidelines on comparing estimates.

Chapter 4 introduces the IEA International Database (IDB) Analyzer Software (IEA, 2024) and presents examples of analyses with the ICILS 2023 data using this software in conjunction with R/RStudio (R Core Team, 2024; RStudio, Inc., 2024), SPSS (IBM Corporation, 2024), and SAS (SAS Institute Inc., 2024).

The user guide is accompanied by the following supplements:

- Supplement 1: International versions of the ICILS 2023 context questionnaires
- Supplement 2: National adaptations to the ICILS 2023 context questionnaires
- Supplement 3: Variables derived from the ICILS 2023 school, teacher, and student data

The primary purpose of this user guide is to introduce users to the ICILS 2023 International Database (IDB) and to demonstrate the basic functionality of the IEA IDB Analyzer through simple examples of results published in the ICILS 2023 International Results. The IEA IDB Analyzer comes with its own manual, available through the Help Module, which describes the full functionality and features of the IEA IDB Analyzer. This user guide also provides references to other ICILS 2023 publications and documentation to facilitate proper interpretation of data analysis results.

About the ICILS 2023 international database

The ICILS 2023 international database includes student, teacher, and school data in R, SPSS, and SAS formats, as well as education system-level data in SPSS format. Accompanying these are a variety of support materials. Table 1.1 provides an overview of the database structure and includes a summary of the support materials available for download.

Table 1.1: Summary of ICILS 2023 international database contents

Data (R, SPSS, SAS)	ICILS 2023 school, teacher, student, national context survey (SPSS only) data files
User guide	User guide and supplements
Data almanacs	Summary statistics for all ICILS 2023 achievement items and context variables
Codebooks	Codebook file describing all variables in the ICILS 2023 international database

Public use and restricted use versions of the ICILS 2023 international database

The ICILS 2023 international database is offered in two versions: a public use version and a restricted use version. The public use version excludes certain variables to reduce the risk of disclosing confidential information. A detailed list of the excluded variables can be found in Chapter 2 of this user guide. This version is readily accessible through the IEA data repository, and it allows users to replicate all published ICILS 2023 findings. Researchers requiring access to the excluded variables for their analyses can request permission for the restricted use version by contacting IEA via the data repository.

References

IBM Corporation. (2024). IBM SPSS Statistics. https://www.ibm.com/products/spss-statistics

IEA. (2024). IEA IDB Analyzer (Version 5.0). https://www.iea.nl/data

R Core Team. (2024). R: A language and environment for statistical computing. https://www.R-project.org/

RStudio, Inc. (2024). RStudio: Integrated Development Environment for R. https://www.rstudio.com/

SAS Institute Inc. (2024). SAS Software. https://www.sas.com/

Chapter 2:

Contents and structure of the ICILS 2023 international database

Tim Daniel

2.1 Overview

The ICILS 2023 international database (IDB) contains student, teacher, and school-level data collected in the 34 countries and one benchmarking participant that participated in the study. The database also includes data from the ICILS 2023 national contexts survey, providing information on the national contexts of computer and information literacy education for all participating countries.

An operational code was assigned to each ICILS 2023 country in the international database (Table 2.1). Twenty-three countries and one benchmarking participant took the optional CT module; four of the ICILS 2023 countries also participated in ICILS 2013 (Table 2.1).

For details on population coverage and exclusion rates for countries that participated in ICILS 2023, please refer to Chapter 6; for details on participation rates, to Chapter 7 of the technical report (Fraillon et al., forthcoming). The database contains materials that provide additional information on its structure and content. This chapter describes the content of the database and is divided into five major sections each covering the different file types and materials included in the database.

Table 2.1: Countries participating in ICILS 2023

Country	Alpha-3	Numeric	CIL	CT	Participated in ICILS 2018	Participated in ICILS 2013
Austria	AUT	40	●	●		
Azerbaijan	AZE	31	●			
Belgium (Flemish)	BFL	965	●	●		
Bosnia and Herzegovina	BIH	70	●			
Chile	CHL	152	●		●	●
Chinese Taipei	TWN	158	●	●		
Croatia	HRV	191	●	●		
Cyprus	CYP	196	●			
Czech Republic	CZE	203	●	●		
Denmark	DNK	208	●	●	●	●
Finland	FIN	246	●	●	●	
France	FRA	250	●	●	●	
Germany	DEU	276	●	●	●	●
Greece	GRC	300	●			
Hungary	HUN	348	●			
Italy	ITA	380	●	●	●	
Kazakhstan	KAZ	398	●		●	
Korea, Republic of	KOR	410	●	●	●	●
Kosovo	XKX	411	●			
Latvia	LVA	428	●	●		
Luxembourg	LUX	442	●	●	●	
Malta	MLT	470	●	●		
Norway	NOR	578	●	●		
Oman	OMN	512	●			
Portugal	PRT	620	●	●	●	
Romania	ROU	9642	●		●	
Serbia	SRB	688	●	●		
Slovak Republic	SVK	703	●	●		
Slovenia	SVN	705	●	●		
Spain	ESP	724	●			
Sweden	SWE	752	●	●		
The Netherlands	NLD	528	●	●		
Uruguay	URY	858	●	●	●	
United States	USA	840	●	●	●	
North Rhine-Westphalia (Germany)	DNW	27,6001	●	●	●	

2.2 Data files

The ICILS 2023 database comprises data from all instruments administered to the students, the teachers teaching in the target grade, the school principals, and the ICT coordinators at the students' respective schools. The data files include the student responses to the computer and information literacy (CIL) and computational thinking (CT) achievement items and the responses to the student, teacher, school, and ICT coordinator questionnaires. The files also contain the achievement scores estimated for participating students, as well as the background variables derived for reporting study findings in Fraillon (2024). National research coordinators' responses to the national contexts survey are also contained in the international database.

This chapter describes the contents and format of the ICILS 2023 data files. These are provided in R (.Rdata), SPSS (.sav) and SAS format (.sas7bdat), except for the national contexts survey data, which are only available in SPSS format (.sav). The files can be downloaded from the IEA Data Repository. Data files are provided for each country that participated in ICILS 2023 where internationally comparable data are available.

The three types of ICILS 2023 data files in the database correspond to the three data levels established in ICILS 2023: school level, student level, and teacher level. Files of the same type include the same uniformly defined set of variables across countries. The file name identifies the type of data file and the country (Table 2.2). For example, BSGLUX2I3.Rdata is an R data file that contains Luxembourg's ICILS 2023 target grade student data. Each file type contains a separate data file for each participating country.

Table 2.2: ICILS 2023 data file names

File names	Description
BSG●●●I3	Student achievement and questionnaire file
BTG●●●I3	Teacher questionnaire file
BCG●●●I3	School and ICT coordinator questionnaire file
NCSICSI3	National contexts survey file

Note: ●●● = three-character alphanumeric country code based on the ISO 3166 coding scheme (Table 2.1)

The SPSS files include full dictionary/meta information, that is, variable name, format (type, width, and decimals), label, value labels, missing values, and appropriately set measurement levels (nominal, ordinal, or scale). The dictionary information can be accessed through the SPSS "View / Variables" menu, or in output form through the "File / Display Data File Information" menu. SAS files include appropriate display formats and variable labels but do not permanently store value labels in data files. In R files, details about variables, mirroring the comprehensive metadata as in the SPSS files, are typically captured using the attributes' function. This displays variable label, missing values, class information, format specifics and value labels. In R (copied from SPSS), variable information is often stored in numeric format. Users may find it necessary to convert these numeric variables to a labeled format, especially when dealing with categorical variables.

All information related to the structure of the ICILS 2023 data files, as well as the source, format, descriptive labels, and response option codes for all variables, are contained in the codebook. Each type of data file in the database is accompanied by a tab in the codebook file in Excel format. The naming convention for the tabs follows the convention for the data files (see Table 2.2) except that the three-letter country acronym is missing.

Please note the SPSS data files are created in Unicode mode. However, when saving SPSS data files in Unicode encoding in code page mode, defined string widths are automatically tripled. These format changes will then cause problems when merging data with the IDB Analyzer (i.e., when merging the data in SPSS). Users should take this into account when saving data files in SPSS.

Student data files (BSG)

Students who participated in ICILS 2023 were administered two of seven CIL test modules, each of which comprised a set of questions and tasks based on a real-world theme and follows a linear narrative structure. Some of these tasks were multiple-choice items, some were constructed-response items, some were automatically scored computer-skills tasks, and others were large authoring tasks that were scored using analytic criteria. The student data files contain the actual responses to the multiple-choice questions and the scores assigned to the constructed-response items, the automatically scored skills items, and the large-task criteria.

Students who participated in ICILS 2023 were also administered a questionnaire that asked them to answer questions related to their home background and their value beliefs, attitudes, and behaviors relevant to CIL (and CT).

The CT test modules followed the student questionnaire session (in countries participating in CT). The CT test consisted of two out of four available test modules, which were administered to all students participating in the CT assessment in a rotated design. In addition to the task types used in the CIL test modules, CT tasks included unique tasks that were assessed using multiple criteria with multiple score categories.

The student data files contain students' responses to these questions. They also contain students' CIL and CT (where applicable) proficiency scores (plausible values). In addition, the student data files feature a number of identification variables, tracking and timing variables, sampling and weighting variables, and derived variables that were used for the analyses described in the international report (see section 2.4 in Fraillon (2024)). In the student data files, each student was assigned a unique identification number (IDSTUD). The IDSTUD can be used to identify individual students within a country, note that all IDs have been scrambled as part of the international data processing work. This means, all student records in the IDB have different IDs assigned than their original ones used during data collection. This is to prevent accidental or deliberate identification of individuals in the data files.

Item response code values

A series of conventions also were adopted to code the data included in the CIL and CT test data files.

The values assigned to each of the test item variables depend on the item format. For multiple-choice items, numerical values from 0 through max 32 correspond to the response options in individual items. 0 always represents an incorrect response whereas all other values represent responses that could be used to assign the final correct or partially correct scores.

The scoring, whether automatic or human, of constructed-response items and large-task criteria used a one-digit scheme. Large tasks in the ICILS 2023 test modules were all scored using task-specific criteria. The manifestation of the assessment criteria across the different tasks depended on the nature of each task. In CIL test modules, some criteria allowed for dichotomous scoring as either 0 (no credit) or 1 (full credit) score points; others allowed for partial credit scoring as 0 (no credit), 1 (partial credit), or 2 (full credit) score points. In CT test modules, some criteria allowed for dichotomous scoring as either 0 (no credit) or 1 (full credit) score points; others allowed for partial credit scoring as 0 (no credit), 1 (partial credit), 2 (partial credit), or 3 (full credit) score points.

The "missing" code ("9" in R and SPSS; "." in SAS) was used when a student made no attempt to answer a task. This code was only allocated when the entire stimulus, question stem, and question response area were left blank by the student. The scoring system automatically allocated the "missing" code and checked whether the response showed any deviation from its initial state.

School data files (BCG)

The school data files contain responses from school principals and ICT coordinators to the questions in the ICILS 2023 principal and ICT coordinator questionnaires. It is to be noted that a series of questions on the use of artificial intelligence, most prominently ChatGPT, were added as an optional block to the principal questionnaire only after the data collection in the northern hemisphere had commenced. Countries from the southern hemisphere could add these questions to their principal questionnaires still whereas northern hemisphere countries were offered a separate, late collection of these additional questions only. Not all national centers were able to contact schools/principals again and also not all countries decided to participate in this option. The following 12 countries chose to administer the additional ChatGPT questions:

- Chile
- Chinese Taipei
- Cyprus
- Denmark
- Greece
- Republic of Korea
- Norway
- Romania
- Slovak Republic
- Slovenia
- Sweden
- Uruguay

Although analysis with schools as investigative units can be performed, it is preferable to analyze school-level variables as attributes of students or teachers. If users want to perform student- or teacher-level analyses with the ICILS 2023 school-level data, they will need to merge the school data files with the student or teacher data files and to use the country and school identification variables to do so. Chapter 4 of this user guide details the IEA IDB Analyzer's merging procedure. Please refer to Table 4.1.

Teacher data files (BTG)

The teachers sampled for participation in ICILS 2023 were asked to complete a questionnaire containing questions pertaining to their background and the organization and culture of the schools where they were teaching. Remaining questions focused on general aspects of teaching with respect to CIL. Each teacher in the teacher data files has his or her own identification number (IDTEACH). This number uniquely identifies each teacher within a country.

It is important to note that the teachers in the ICILS 2023 teacher data files constitute a representative sample of target-grade teachers in a country. However, student and teacher data must not (and cannot) be merged at the level of individuals because these two groups constitute separate, albeit related, target populations. Chapter 4 of this user guide describes how the IEA IDB Analyzer software can be used to conduct student-level analyses with teacher data.

Questionnaire response code values

A series of conventions were adopted to code the data included in the ICILS 2023 questionnaire data files.

The values assigned to each of the questionnaire variables depend on the item format and the number of options available. For categorical questions, sequential numerical values were used to correspond to the response options available. The numbers correspond to the sequence of appearance of the response options. For example, the first response option is represented with a 1, the second response option with a 2, and so on. Check-all-that-apply questions were coded as "checked" if the corresponding option was chosen, otherwise it was coded as "not checked." Open-ended questions, such as "the number of female students in a school," were coded with the actual number given as a response.

National contexts survey data file

This data file contains the responses provided by national research coordinators of the participating countries to the ICILS 2023 national contexts survey. The national contexts survey was designed to systematically collect relevant data on the structure of the education system, education policy, and computer and information literacy education, teacher qualifications for CIL education, and information about national debates and reforms. The survey also collected data on processes at the national level related to assessment of and quality assurance in CIL education and school curriculum approaches. The national contexts survey was administered online and was generated using SoSci Survey (Leiner, D. J., 2024).

The national contexts survey data file (NCSICSI3.sav) is available in SPSS format and contains data for all 34 countries participating in ICILS 2023 as well as the benchmark participant.

2.3 Records included

The international database includes all records that satisfied the international sampling standards. Data from those respondents who either did not participate or did not pass adjudication because, for example, within-school participation was insufficient, were removed from the final database.

More specifically, the database contains records for the following:

- All participating schools: any school where the school principal responded to the principal questionnaire and/or the ICT coordinator responded to the ICT coordinator questionnaire has a record in the school-level files. Participation in ICILS 2023 at school level is independent of participation at the student and/or teacher levels for the same school.
- All participating teachers: any teacher who responded to the teacher questionnaire has a record in the teacher-level files, provided that at least 50 percent of the sampled teachers of that school participated in the study.
- All participating students: any student who responded to at least one item of the student test or questionnaire has a record in the student-level files, but only if at least 50 percent of the students of the sampled class of that school took part in ICILS 2023.

Consequently, the following records were excluded from the database:

- Schools where both the principal and the ICT coordinator did not respond to the questionnaire;
- Students who could not or refused to participate or did not respond to a single item of the student test or questionnaire;
- Students who experienced a technical failure of the electronic assessment system during test administration and were consequently unable to complete the assessment;
- Students from those schools where less than 50 percent of the students of the sampled class participated;
- Teachers who did not respond to the questionnaire;
- Teachers from those schools where less than 50 percent of the sampled teachers participated;

- Students and/or teachers who were afterwards reported as not in scope, not eligible, or excluded;
- Students or teachers who participated but were not part of the sample; and
- Any other records that were considered unreliable, of undocumented origin, or otherwise in violation of accepted sampling and adjudication standards.

Any additional data collected by countries to meet national requirements were also excluded from the international database.

For further information on the ICILS 2023 participation and sampling adjudication requirements, refer to Chapter 7 of the technical report (Fraillon et al., forthcoming).

2.4 Variable naming convention and response codes

The database contains the following information for each school that participated in the survey:

- The identification variables for the country and school;
- Additional administrative variables;
- Additional structure and design variables;
- The school principal's responses to the principal questionnaire (including the optional ChatGPT questions if applicable);
- The ICT coordinator's responses to the ICT coordinator questionnaire;
- The school indices derived from the original questions in the principal and ICT coordinator questionnaires; and
- Weights and variance estimation variables pertaining to schools.

The information in the database for each teacher who participated in the survey is as follows:

- The identification variables for the country, school, and teacher;
- Additional administrative variables;
- Additional structure and design variables;
- The teacher's responses to the teacher questionnaire;
- The teacher indices derived from the original questions in the teacher questionnaire; and
- The weights and variance estimation variables pertaining to teachers.

For each student who participated in the survey, the following information is available:

- The identification variables for the country, school, and student;
- The student's responses to the student questionnaire;
- Selected student's raw responses to the student CIL test;
- Selected student's raw responses to the student CT test, if applicable;
- Additional structure and design variables;
- The student CIL test scores;
- The student CT test scores, if applicable;
- Selected process information for CT items;

- Timing information, i.e., the time students spent on each task and module;
- The student indices derived from the original questions in the student questionnaire; and
- The weights and variance estimation variables pertaining to students.

The following sections offer more detailed explanations of these variables.

Identification variables

All ICILS 2023 data files contain several identification variables that provide information to identify countries and entries of students, teachers, or schools (Table 2.3). These variables are used to link variables of one case, clusters of cases (students belonging to specific classes and teachers pertaining to specific schools), and cases across the different types of data file. However, the variables do not allow identification of individual schools, students, or teachers in a country.

IDCNTRY indicates the country or participating education system that the data refers to as an up to six-digit numeric code based on the ISO 3166-1 classification (Table 2.1), with adaptations reflecting the education systems participating. This variable should always be used as the first linking variable whenever files are linked within and across countries.

CNTRY indicates the participant's three-digit alphanumeric code, based on the ISO 3166-1 coding, with adaptations reflecting the education systems participating.

IDSCHOOL is a four-digit identification code that uniquely identifies the participating schools within each country. The school codes are not unique across countries. Schools across countries can only be uniquely identified by the combination of IDCNTRY and IDSCHOOL.

IDCLASS is a six-digit identification code that uniquely identifies a participating class in a school. The first four digits of IDCLASS contain the IDSCHOOL code for the school, thus identifying a class within a school.

IDSTUD is an eight-digit identification code that uniquely identifies each sampled student within a country. Students can be uniquely identified across countries using the combination of IDCNTRY and IDSTUD. The first four digits of IDSTUD contain the IDSCHOOL code for the student's school, the 5th and 6th digit indicates the class within this school, and, thus identifying a student within a specific class within a school.

IDTEACH is a six-digit identification code that uniquely identifies the sampled teacher within a country. Teachers can be uniquely identified across countries using the combination of IDCNTRY and IDTEACH. The first four digits of IDTEACH contain the IDSCHOOL code for the teacher's sampled school.

As for reasons of confidentiality, the identification variables for the student (IDSTUD), teacher (IDTEACH), class (IDCLASS), and school (IDSCHOOL) were scrambled, they did not match the identifiers used during data collection. However, the structural link between the school and student/teacher level (the variable IDSCHOOL in the student and teacher files and the first four digits of any IDSTUD/IDTEACH variable) was maintained for all countries. Similarly, also the structural link between the class and student level (the variable IDCLASS in the student files and the first six digits of any IDSTUD variable) was maintained. For each country, unique matching tables were created and made available to authorized individuals.

Table 2.3: Location of identification variables in the ICILS 2023 international database

Identification variables	BCG	BSG	BTG
IDCNTRY	●	●	●
CNTRY	●	●	●
IDSCHOOL	●	●	●
IDCLASS		●	
IDSTUD		●	
IDTEACH			●

Notes: BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

Administration variables

The international database includes several variables that provide additional information about survey administration, participation in the study, and other basic characteristics of respondents (Table 2.4).

IDLANG_PrQ indicates the language used in the principal questionnaire. The numeric language codes are based on the Microsoft LCID (Language Code Identifier) standard.

IDLANG_CoQ indicates the language used in the ICT coordinator questionnaire. The numeric language codes are based on the Microsoft LCID standard.

BOOKLET identifies the specific instrument version that was administered to each student via the electronic ICILS 2023 assessment software. The instrument versions are given a numerical value that ranges from 511 through 594 for countries who administered CIL and CT test modules and from 811 through 852 for countries who administered CIL test modules only.

ITLANGS indicates the language(s) in which the student test was written in a country and which each student was required to use when working through the assessment. The numeric language codes are based on the Microsoft LCID standard.

TADATE indicates the date (day/month/year) when the test was administered to the student.

IDLANG_TcQ represents the language used in the teacher questionnaire. The numeric language codes are based on the Microsoft LCID standard.

Table 2.4: Location of administration variables in the ICILS 2023 international database

Administration variables	BCG	BSG	BTG
IDLANG_PrQ	●		
IDLANG_CoQ	●		
BOOKLET		●	
ITLANGS		●	
TADATE		●	
IDLANG_TcQ			●

Notes: BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file.

Achievement item variables

There are three types of achievement items on the data files, variables holding raw responses as collected in the field, variables holding the final, sometimes composite, score for a task, and variables holding the timing information on a task in seconds.

The names of the raw achievement item and timing variables pertaining to the international test are based on an alphanumeric code. These codes consist of up to seven characters and a suffix, and adhere to the following rules:

- The first character indicates the general study context. "C" stands for computer and information literacy and "T" for computational thinking.
- The second character indicates the assessment cycle when the item was first used in ICILS. It is therefore "1" for all items introduced as part of the ICILS 2013 assessment, "2" for items developed for ICILS 2018, and "3" for items developed for the 2023 cycle.
- The third character represents the test module the item belongs to. The following letters are used to indicate the test modules:
  - "C" indicates the "Computer Use and Health" module
  - "I" indicates the "Internet Safety" module
  - "P" indicates the "Paper Books vs E-books" module
  - "T" indicates the "Activity Tracker" module
  - "G" indicates the "Board Games" module
  - "H" indicates the "Breathing" module
  - "R" indicates the "Recycling" module
  - "S" indicates the "School Trip" and the "Suns and Moons" module
  - "A" indicates the "Automated Bus" module
  - "F" indicates the "Farm Drone" module.
- The fourth and fifth characters indicate the item number of the test module.
- The sixth character is used for multipart items ("A," "B," "C," etc.) where "Z" is used for items not split into multiple parts.
- The seventh digit represents the original item type. "M" represents multiple-choice items; "A" represents items that were automatically scored, and "C" stands for items that were manually scored.
- The final two characters / the suffix indicate the use of the item. "_S" is used as suffix for all variables that were used in scaling, items available in the achievement data but not used to calculate a score are treated as process data are indicated by suffix "_P," and all timing variables carry a "_T" suffix.

For example, C1H02ZA_P is the second item from the student CIL test module "Breathing." It is a multiple-choice item, automatically scored, and was first developed for use in ICILS 2013. It is additional process information and was not used in scaling.

The names of the achievement item variable holding the final (composite) score for CIL modules consist of six characters and a suffix, and adhere to the following rules:

- The first character indicates that this is a CIL item and is "C" in all instances.
- The second character indicates the assessment cycle when the item was first used in ICILS. It is therefore "1" for all items introduced as part of the ICILS 2013 assessment, "2" for items developed for ICILS 2018 and "3" for items developed for the 2023 cycle.

- The third character represents the test module the item belongs to. The following letters are used to indicate the test modules:
  - "C" indicates the "Computer Use and Health" module
  - "I" indicates the "Internet Safety" module
  - "P" indicates the "Paper Books vs E-books" module
  - "G" indicates the "Board Games" module
  - "H" indicates the "Breathing" module
  - "R" indicates the "Recycling" module
  - "S" indicates the "School Trip" module.
- The fourth and fifth characters indicate the item number of the test module.
- The sixth character is used for multipart items ("A", "B", "C", etc.) where "Z" is used for items not split into multiple parts.
- The final two characters / the suffix indicate the use of the item. "_S" is used as suffix for all variables that were used in scaling, items available in the achievement data but not used to calculate a score are treated as process data are indicated by suffix "_P", and all timing variables carry a "_T" suffix.

For example, CH01Z_S is the variable name of the first item from the student CIL test module "Breathing" and it was used in scaling. An exception to the rule, with more characters, is item CI07AB_S which is a composite score of tasks 7A and 7B of test module "Internet Safety."

The names of the achievement item variables holding the final (composite) score for CT modules consist of six characters and adhere to the following rules:

- The first character indicates that this is a CT item and is "T" in all instances.
- The second character indicates the assessment cycle when the item was first used in ICILS. It is therefore "1" for all items introduced as part of the ICILS 2013 assessment, "2" for items developed for ICILS 2018 and "3" for items developed for the 2023 cycle.
- The third character represents the test module the item belongs to. The following letters are used to indicate the test modules:
  - "T" indicates the "Activity Tracker" module
  - "S" indicates the "Suns and Moons" module
  - "A" indicates the "Automated Bus" module
  - "F" indicates the "Farm Drone" module.
- The fourth and fifth characters indicate the item number of the test module.
- The sixth character is used for multipart items ("A", "B", "C", etc.) where "Z" is used for items not split into multiple parts and "L" for items from large tasks.
- The final two characters / the suffix indicate the use of the item. "_S" is used as suffix for all variables that were used in scaling, items available in the achievement data but not used to calculate a score are treated as process data are indicated by suffix "_P", and all timing variables carry a "_T" suffix.

For example, TA02Z_S is the variable name of the second item from the student CT test module "Automated Bus" and it was used in scaling. An exception to the rule, are a few items from the "Farm Drone" module which have slightly deviating name endings.

Achievement test scores

The ICILS 2023 research team produced student computer and information literacy (CIL) and computational thinking (CT) achievement scales. Chapter 11 of the technical report (Fraillon et al., forthcoming) provides detailed descriptions of the ICILS 2023 scaling and the CIL and CT achievement scales, including their construction. The international database provides five separate estimates of each student's score on CIL and, if applicable, the CT scales. These are contained in the student file. The variability between the five estimated scores, known as "plausible values," encapsulates the uncertainty inherent in the scale estimation process.

The plausible values for the CIL and CT scales are the best available measures of student achievement on these scales in the international database and should therefore be used as the outcome measure in any study of student achievement. Plausible values can be readily analyzed using the IEA IDB Analyzer, described in detail in Chapter 4 of this user guide.

The five achievement score variable, i.e., plausible value, names are PV1CIL to PV5CIL for the CIL and PV1CT to PV5CT for the CT scale.

Questionnaire variables

The questionnaire variable names consist of a 6- to 8-character string (e.g., IS3G04A). The following rules are applied in naming the variables of the international and national instruments:

- The first character indicates the reference level. The letter "I" is used for variables that are administered on an international level.
- The second character indicates the type of respondent. The letter "C" is used to identify data from school principals and the letter "A" is used to identify data from the optional ChatGPT questions within the principal questionnaire, while the letter "I" is used for ICT-coordinator data. The letter "T" is used for teacher data. The letter "S" is used for student data.
- The third character indicates the study cycle. Number "3" identifies ICILS 2023 as the third cycle of this IEA study.
- The fourth character is used to indicate the context of the variable. The letter "G" is used for general contexts.
- The fifth and sixth characters indicate the question number.
- The seventh and eighth characters represent optional digits for multipart items, and optional digits for multipart subitems, respectively.

The values assigned to each of the questionnaire variables depend on the questionnaire item format and the number of options available. For categorical questions, sequential numerical values are used that correspond to the response options available. The numbers correspond to the sequence of appearance of the response options. For example, the first response option is represented with a 1, the second response option with a 2, and so on. Open-ended questions, such as "number of students in a school," are coded with the actual number given as a response.

The raw information collected by the questionnaires underwent extensive processing, inspection, cleaning, and editing. Out-of-range values, questions determining the flow of the questionnaire, and inconsistent or implausible combinations of responses were inspected and cleaned where necessary. To address residual inconsistencies, ICILS 2023 imposed certain automatic edits, for example, the removal of implausible responses, for all countries. For further information on data collection, capturing, processing, editing, weighting, and adjudication of the international database, please consult Chapters 7 and 10 of the technical report (Fraillon et al., forthcoming).

With respect to the international database, the data-cleaning process at IEA Hamburg ensured that information coded in each variable would be internationally comparable. National adaptations were reflected appropriately in all concerned variables, and questions that were not internationally comparable were removed from the database. For more information on national adaptations and their eventual handling, consult Supplement 2 of this user guide.

Indices, ratios, and indicators derived from the questionnaire data

Several questions asking about various aspects of a single construct appear frequently in the ICILS 2023 questionnaires. In these cases, the ICILS research team combined responses to the individual items to create a derived variable that provided a more comprehensive picture of the construct of interest than the individual variables could on their own.

The international database contains scale indices derived from scaling of items, a process typically achieved by using item response modeling of dichotomous or Likert-type items. Questionnaire scales derived from weighted likelihood estimates (logits) present values on a continuum with an ICILS average of 50 and a standard deviation of 10 (for equally weighted national samples). The database also contains other indices that were derived by simple recoding or arithmetical transformation of original questionnaire variables.

Supplement 3 of this user guide provides a description of all derived variables included in the international database. For further information about the scaling procedure for questionnaire items, please refer to Chapter 12 of the technical report (Fraillon et al., forthcoming).

Weighting and variance estimation variables

To allow for calculation of the population estimates and correct jackknife variance estimates, the data files provide sampling and weighting variables. Further details about weighting and variance estimation are provided in Chapter 3 of this user guide.

Each record in the ICILS 2023 international database contains one or more variables that reflect the record's selection probabilities (or base weights) and nonresponse adjustment(s). The last character of the variable name indicates the data type (student = S, teacher = T, school = C). The weights and weighting factors differ depending on the data type. The only value identical in all three types of datasets is the value for the school base weight (variable WGTFAC1). This is because the school sampling comprised universally the first sampling stage and is therefore independent of data type. Each data file contains an estimation or final weight variable. Each such variable starts with the letters "TOT" (i.e., the product of all other weight variables) and must be used for single-level analyses.

The ICILS 2023 international database includes the following weight variables (Table 2.5). TOTWGTC is the final school weight for schools. It is computed as the product of WGTFAC1 and WGTADJ1C. The final school weight for schools must be applied when analyzing the data coming from the school questionnaire.

TOTWGTS is the final student weight. It is computed as the product of WGTFAC1, WGTADJ1S, WGTFAC2S, WGTADJ2S, WGTFAC3S, and WGTADJ3S. The final student weight must be applied when analyzing the students' data.

TOTWGTT is the final teacher weight. It is computed as the product of the WGTFAC1, the WGTADJ1T, WGTFAC2T, WGTADJ2T, and WGTADJ3T. The final teacher weight must be applied when analyzing the teacher's data.

WGTADJ1C is the school weight adjustment for schools. It accounts for the non-returned school-level questionnaires. The adjustment is done within explicit strata.

WGTADJ1S is the school weight adjustment for students. It accounts for the non-participating schools regarding the student survey. The adjustment is done within explicit strata.

WGTADJ1T is the school weight adjustment for teachers. It accounts for the non-participating schools regarding the teacher questionnaire. The adjustment is done within explicit strata.

WGTADJ2S is the class weight adjustment for non-participating classes. The adjustment is done within explicit strata.

WGTADJ2T is the teacher weight adjustment. It accounts for the non-participating teachers. The adjustment is done within schools.

WGTADJ3S is the student weight adjustment. It accounts for the non-participating students. The adjustment is done within classes.

WGTFAC1 is the school base weight. It corresponds to the inverse of the selection probability of the school.

WGTFAC2S is the class base weight. It corresponds to the inverse of the selection probability of the class.

WGTFAC2T is the teacher weight factor. It corresponds to the inverse of the selection probability of the teacher within the school.

WGTFAC3S is the student base weight. It corresponds to the inverse of the selection probability of the student.

WGTFAC3T is the teacher multiplicity adjustment. It accounts for teachers teaching in more than one school.

Table 2.5: Location of weighting variables in the ICILS 2023 international database

Weighting variables	**BCG**	**BSG**	**BTG**
TOTWGTC	●		
TOTWGTS		●	
TOTWGTT			●
WGTADJ1C	●		
WGTADJ1S		●	
WGTADJ1T			●
WGTADJ2S		●	
WGTADJ2T			●
WGTADJ3S		●	
WGTFAC1	●	●	●
WGTFAC2S		●	
WGTFAC2T			●
WGTFAC3S		●	
WGTFAC3T			●

Notes: BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

A variance estimation method that considers the structure of the data is the jackknife repeated replication (JRR) method. The ICILS 2023 international database contains variables that support the implementation of this method (i.e., "jackknife zone," "jackknife replicate," "replicate weights"); we strongly encourage database users to use them. As the IEA IDB Analyzer automatically recognizes the data structure of ICILS 2023, it reports correct standard errors for all estimates using JRR with the respective variables.

Several variance estimation variables (or "jackknife variables") are included in the ICILS 2023 international database (Table 2.6). The actual replicate weights are computed "on-the-fly" within the IEA IDB Analyzer, but, as researchers may wish to conduct analyses without using the IEA IDB Analyzer, these variables are also presented within the data.

JKZONEC indicates the sampling zone where the school belongs. The values of JKZONEC can vary between 1 and 75. This variable is used to estimate sampling errors when analyzing school-level data.

JKREPC can take the values 0 or 1. It indicates if the school should be deleted or its weight doubled when estimating sampling errors.

The variables CRWGT1 to CRWGT75 indicate the jackknife replicate weights variables (1–75) for the school survey.

JKZONES indicates the sampling zone where the student belongs. The values of JKZONES can vary between 1 and 75. This variable is used to estimate sampling errors when analyzing student data.

JKREPS can take the values 0 or 1. This variable indicates whether the student should be deleted or its weight doubled when estimating sampling errors.

The variables SRWGT1 to SRWGT75 indicate the jackknife replicate weights variables (1–75) for the student survey.

JKZONET indicates the sampling zone where the teacher belongs. The values of JKZONET can vary between 1 and 75. This variable is used to estimate sampling errors when analyzing teacher data.

JKREPT can take the values 0 or 1. This variable indicates whether the teacher should be deleted or its weight doubled when estimating sampling errors.

The variables TRWGT1 to TRWGT75 indicate the jackknife replicate weights variables (1–75) for the teacher questionnaire.

Table 2.6: Location of variance estimation variables in the ICILS 2023 international database

Variance estimation variables	BCG	BSG	BTG
JKZONEC	●		
JKREPC	●		
CRWGT1 to CRWGT75	●		
JKZONES		●	
JKREPS		●	
SRWGT1 to SRWGT75		●	
JKZONET			●
JKREPT			●
TRWGT1 to TRWGT75			●

Notes: BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

Database creation variables

Information about the version number of the ICILS 2023 international database and the date of its creation at IEA Hamburg is contained in the database creation variables. They are included in all data files.

VERSION indicates the system of database version numbers was used throughout the data processing process. The version number of the ICILS 2023 final database is "4.0" or higher.

IEADATE specifies the date when IEA Hamburg produced the data file.

2.5 Codes for missing data

A subset of the values for each variable type was reserved for specific codes related to different categories of missing data. We recommend that the user reads the following section with particular care since the way in which these missing codes are used may have major consequences for analyses.

Omitted response codes (SPSS and R: 9, 99, 999, ...; SAS: .)

"Omitted" response codes are used for questions or items that a student, teacher, or school principal should have answered but did not, i.e., an omitted response code is given when an item is left blank. The length of the omitted response code given to a variable in the SPSS and R data files depends on the number of characters needed to represent the variable. For example, the omitted code for a one-digit variable is "9," whereas the omitted code for three-digit variables would be "999."

Not administered response codes (SPSS and R: 8, 98, 998, ...; SAS: .A)

Specific codes were given to items that were "not administered" to distinguish these from data that were missing due to non-response. The not administered code was used in the following cases:

- CIL test item was not assigned to the student: All students participating in ICILS 2023 CIL test received only two of the seven CIL test modules. All variables corresponding to items that were not part of the modules assigned to a student were coded as "not administered."
- CT test item was not assigned to the student: The ICILS 2023 IDB includes CT-related variables even for countries that did not participate in the CT module. All variables corresponding to items that were not part of the assigned CT test module were coded as "not administered."
- Student was absent from test session: When a student did not attend a particular testing session, for example because of sickness, all variables relevant to that session were coded as "not administered."
- The achievement item was not displayed to the student due to a technical failure of the electronic assessment system: If the assessment system failed during the assessment, all variables following the last item presented to a student when the failure occurred (i.e., assuming there was still time left to complete the corresponding test module) were coded as "not administered" (see Chapter 11 in the technical report (Fraillon et al., forthcoming).
- Question or item deleted or mistranslated: A question or item identified during translation verification or item review as having a translation error, such that the nature of the question was altered, or as having poor psychometric properties, was coded as "not administered" if it could not be recoded to match as closely as possible the international version.
- A questionnaire was returned empty, was not returned, or was lost: All variables referring to that instrument and any derived variables were coded as "not administered."
- A country chose, for cultural reasons, not to administer (include) a certain question in its national questionnaire: The variables corresponding to the removed question were coded as "not administered." Supplement B of this user guide provides details on the national adaptations.

The length of the not administered response code in the SPSS and R data files depends on the number of characters needed to represent the variable. For example, the not administered code for a one-digit variable is “8,” whereas the not administered code for three-digit variables would be “998.”

Not reached response codes (SPSS and R: 7; SAS: .R)

An item was considered “not reached” in the achievement data files when the item itself and the item preceding it were not answered and when (1) no other items were completed in the remainder of the test module, and (2) no technical failure of the electronic student assessment system occurred.

Logically not applicable response codes (SPSS and R: 6, 96, 996, …., SAS: .B)

“Logically not applicable” response codes were used for the questionnaire items for which responses were dependent on a filter question. If the filter question was answered such that the following questions would not apply any follow-up question has been coded as “logically not applicable.”

The length of the logically not applicable response code in the SPSS and R data files depends on the number of characters needed to represent the variable. For example, the logically not applicable code for a one-digit variable is “6,” whereas the logically not applicable code for three-digit variables would be “996.”

Important note on handling missing data in the R, SPSS, and SAS source files

It is strongly recommended to use the IDB Analyzer for all analyses involving ICILS 2023 data. However, the source files utilized by the IEA IDB Analyzer can also be opened with corresponding statistical software packages. In such cases, it is important to understand how each software package handles missing data.

SPSS files include numeric user-defined missing values, which are properly recognized and accounted for in any analysis. Similarly, SAS data files use alphanumeric missing codes, which are also treated as missing values during analysis.

When using R data files (*.Rdata) without the IDB Analyzer for analysis, it is crucial to understand how missing data is represented and handled. In R, there is only one true native missing code: NA. However, the R data files were originally created from SPSS files, where multiple user-defined missing codes can be represented as specific numeric values.

For example, in the SPSS files, missing codes for “omitted” responses are often represented as 9, 99, 999, etc., while “not reached” codes in the achievement files are represented as 6, 96, 996, and so on (see above for details).

If you analyze the R data files directly in R or RStudio without addressing these user-defined missing codes, your estimates will likely be incorrect. This is because R interprets these values as valid numeric data rather than missing values. To ensure accurate analysis in R you must recode all numerical missing codes to R’s native missing code, NA, before proceeding with your analysis.

To determine which numeric values have been defined as missing values, you can check directly in your R data file by executing the following command line:

attr(<your R data file>$<variable of interest>, “na_values”)

Alternatively, you can consult the “Missing Scheme Detailed (SPSS)” column in the ICILS codebook. This resource provides the necessary details for correctly identifying and handling missing data. This should also be taken into account when you add variables to your R data files.

This is an additional key reason why it is highly recommended to use the IEA IDB Analyzer for your analysis.

2.6 Codebooks

All information related to the structure of the ICILS 2023 data files, as well as the source, format, descriptive labels, and response option codes for all variables, is contained in a codebook file in Excel format.

In the codebook file, there is a tab for each appropriate data file type in the ICILS 2023 international database. These tabs describe the contents and structure of the respective data file. Important codebook fields include "Label," which contains extended textual information for all variables, "Value Scheme Detailed," which lists the acceptable responses allowed for each variable, and "Missing Scheme Detailed," which lists all applicable missing codes in R/SPSS and SAS.

Two versions of the ICILS 2023 international database

To protect the confidentiality of the study respondents, ICILS 2023 applied certain disclosure avoidance measures at the international level. These measures were consistent across all countries. These measures were implemented for all data versions and exports of the database that participating countries and public users can access. Indirect identification of individuals was prevented by applying international disclosure risk edits, such as scrambling of identification variables and jackknife zone information. Furthermore, some of the personal data variables that were needed only during field operations and data processing were removed, and variables that were identified as highly identifying were suppressed or categorized.

The ICILS 2023 international database is available in two versions: a public use file (PUF) and a restricted use file (RUF). The public use version is available for immediate access from the IEA Data Repository. A number of variables have been removed or categorized from the public use version in order to minimize the risk of disclosing confidential information or allow re-identification. Users will be able to replicate all published ICILS 2023 results with this version of the ICILS 2023 international database. The restricted use file is an extended version for scientific use. Users who require any of the removed variables to conduct their analyses should contact IEA through its IEA Data Repository to obtain permission and access to the restricted use version of the ICILS 2023 international database.

Some variables in the restricted and the public use versions of the ICILS 2023 international database have been scrambled, categorized, or removed for differing reasons (see Table 2.7, Table 2.8, and Table 2.9). More details for all these variables are available in the codebook files.

Table 2.7: Disclosure risk edits for sampling, identification, and tracking variables

Variables	Description	Location of data files	RUF	PUF
IDSCHOOL / IDSTUD / IDTEACH	Identification variable	BCG, BTG, BSG	Scrambled	Scrambled
JKZONEC/T/S	Jackknife zones	BCG, BTG, BSG	Scrambled	Scrambled
STEACHERS	Number of teachers to sample	BCG	Included	Suppressed
NTEACHERS	Number of teachers in target grade	BCG	Included	Suppressed
ITBIRTHY_S, ITBIRTHM_S	Students' year/month of birth from tracking forms	BSG	Included	Suppressed
ITBIRTHY_T	Teachers' year of birth from tracking forms	BTG	Included	Suppressed
TADATE	Date of testing	BSG	Included	Suppressed

Notes: RUF = restricted use file; PUF = public use file; BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

Table 2.8: Disclosure risk edits for school questionnaire variables

Variables	Description	Location of data files	RUF	PUF
IP3G23	Principal's age	BCG	Included	Suppressed
IP3G22	Principal's gender	BCG	Included	Suppressed
IP3G06A	Public or private school	BCG	Included	Suppressed
P_PRIV	Public or private school - derived	BCG	Included	Suppressed
IP3G01A / IP3G01B	Total enrollment	BCG	Included	Suppressed
P_NUMSTD	Total enrollment - derived	BCG	Included	Categorized
IP3G02A / IP3G02B	Enrollment <target grade>	BCG	Included	Suppressed
P_NUMTAR	Enrollment <target grade> - derived	BCG	Included	Categorized
IP3G04A / IP3G04B	Total number of full-time and part-time teachers	BCG	Included	Suppressed
P_NUMTCH	Total number of full-time and part-time teachers - derived	BCG	Included	Categorized

Notes: RUF = restricted use file; PUF = public use file; BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

Table 2.9: Disclosure risk edits for student questionnaire variables

Variables	Description	Location of data files	RUF	PUF
IS3G01A, IS3G01B	Students' date of birth (month, year)	BSG	Incuded	Suppressed
IS3G02	Student's gender	BSG	Included	Suppressed

Notes: RUF = restricted use file; PUF = public use file; BCG = school and ICT coordinator questionnaire file; BSG = student achievement and questionnaire file, BTG = teacher questionnaire file

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Chapter 3:

Weights and variance estimation for ICILS 2023

Sabine Tieck

3.1 Overview

This chapter introduces the use of weight and variance estimation variables in the ICILS 2023 student, teacher, and school-level data analyses; and its content is largely based on Chapter 3 of the ICILS 2013 User Guide (Jung & Carstens, 2015). The examples outlined here demonstrate the importance of using appropriate weight variables and variance estimation techniques to achieve a correct estimation of population parameters and calculate standard errors that correctly reflect the uncertainty of these parameters. It is important to account for the design of the ICILS survey if researchers are to draw the correct conclusions about the population under study. This chapter also includes a discussion of constraints for specific analysis types (e.g., when simultaneously using data from different sources) and the constraints for multi-level analysis—comparing ICILS 2023 results to earlier cycles—which come with the changes of the method to select students.

3.2 Which weights to use for which analysis

All data in the ICILS 2023 international database were derived from randomly drawn samples of schools, students, and teachers. In order to achieve unbiased estimates of the target population under study, database users and analysts must take into account the complex nature of the sampling design implemented in each ICILS education system. Chapter 6 of the ICILS 2023 technical report (Fraillon et al., forthcoming) provides details about the sampling design of ICILS 2023.

This complex sampling design resulted in varying selection probabilities for sampled schools, students, and teachers. Another consideration arising out of this design is that the varying non-participation patterns of schools among strata and of students or teachers within participating schools can lead to biased estimates. All units participating in ICILS 2023 have sampling weights that consider these two design characteristics, allowing an unbiased estimation of population parameters. Chapter 7 of the ICILS 2023 technical report (Fraillon et al., forthcoming) elucidates on the weighting and non-participation adjustments.

Sampling weights were calculated independently for the ICILS 2023 student, teacher, and school survey to enable correct analyses of the data.

Sampling weight variables in the ICILS 2023 international database

The ICILS 2023 international database contains a set of weight variables for each population. For the student population, seven student weight variables are included in the BSG file (see Table 3.1); for the teacher population, six weight variables are included in the BTG files (see Table 3.2); and the three school weight variables are included in the school and ICT coordinator questionnaire file (see Table 3.3). For a full description of the weight variables, see Table 2.5.

Table 3.1: Student weight variables

Variable	Description	IDB Analyzer file
TOTWGTS	Final student weight	BSG - the student achievement and questionnaire file
WGTFAC1	School base weight	
WGTADJ1S	School weight adjustment - student study	
WGTFAC2S	Class base weight - student study	
WGTADJ2S	Class weight adjustment - student study	
WGTFAC3S	Student base weight	
WGTADJ3S	Student weight adjustment	

Table 3.2: Teacher weight variables

Variable	Description	IDB Analyzer file
TOTWGTT	Final teacher weight	BTG - the teacher questionnaire file
WGTFAC1	School base weight	
WGTADJ1T	School weight adjustment - teacher study	
WGTFAC2T	Teacher base weight	
WGTADJ2T	Teacher weight adjustment	
WGTFAC3T	Teacher multiplicity adjustment	

Table 3.3: School-level weight variables

Variable	Description	IDB Analyzer file
TOTWGTC	Final school weight	BCG - the school and ICT coordinator questionnaire file
WAGFAC1	School base weight	
WGTADJ1C	School weight adjustment - school study	

Importance of using weights for data analysis

Researchers analyzing ICILS 2023 data must use sampling weights that consider the study's complex sample design to obtain unbiased population estimates. The choice of the correct sampling weights will depend on the type of data used and the level of analysis.

Generally, the sampling design used for ICILS leads to self-weighted samples for the student population, where the sampling units have similar final estimation weights. This is achieved by assigning low selection probabilities to small schools but high selection probabilities to students within small schools and, vice versa, high selection probabilities to large schools but low selection probabilities to students within large schools. The within-school selection probability is dependent on the number of classes with target grade students. In large schools with more classes, the selection probability for a student is smaller than in small schools with a low number of classes. The product of the two base weights (school and class weight) is then similar for all students. See Meinck, 2015 for further reading on this matter. Please note that the sampling design was optimized for the student population, resulting not automatically in self-weighted samples for the teacher population and school-level data. Certain circumstances, briefly described below, explain a high variation between the estimation weights of sampled units. These make using weights in all ICILS 2023 data analysis essential if biased results are to be avoided. In other words, not using weights in data analysis can lead to severely biased results:

- Explicit stratification and disproportional sample allocation was commonly used. This practice would lead to variation in school selection probabilities.
- Non-response patterns vary in accordance with non-response adjustment cells (i.e., strata or schools). For instance, individual student weights in a class with a response rate of just over 50 percent would be almost twice as large as those from a class where all sampled students participated. Note that those student (teacher) in classes (schools) with response rates below 50 percent are considered as refusals for the respective survey and not included in the ICILS 2023 international database.
- Using the sampling design for selecting schools resulting in base weights for schools depending on their size (i.e., number of grade 8 students), with larger schools having higher selection probabilities than smaller schools. If weights are ignored for any school-level analysis, large schools will be overrepresented. The following example illustrates this. In an estimate of the average number of full-time teachers per school in Chinese Taipei (variable IP3G04A in file BCGTWNI3), the unweighted (hence incorrect) estimate is 93.9, while the (correctly) weighted estimate is considerably smaller (68.3). This difference is due to the sampling design, which leads to a sample that contains more large schools than are actually present in the population, and of course, large schools also have more teachers on staff than small schools.
- Using the sampling design for selecting teachers: the correlation between the numbers of grade 8 students in schools (used as the measure of size for determining school selection probabilities) and grade 8 teachers is only moderate. The teacher selection probabilities accordingly vary by design.

Our next example illustrates the importance for using weights for the student study. Imagine a researcher is interested in ascertaining the CIL average in Chinese Taipei (variables PV1CIL–PV5CIL in the BSG file) and is using (e.g., in SPSS) unweighted data. The mean of each plausible value is calculated and the average score turns out to be 508.23 (see Figure 3.1).

Figure 3.1: Example of unweighted analysis in SPSS

» Check Analysis Variables - Unweighted Statistics

Descriptives

Descriptive Statistics

Country ID - Numeric Code		N	Minimum	Maximum	Mean	Std. Deviation
158	Computer and Information Literacy- 1ST PV	5112	187	789	508.53	88.033
	Computer and Information Literacy- 2ND PV	5112	145	787	508.20	87.414
	Computer and Information Literacy- 3RD PV	5112	180	800	508.16	88.325
	Computer and Information Literacy- 4TH PV	5112	108	792	508.05	89.390
	Computer and Information Literacy- 5TH PV	5112	126	760	508.20	88.140
	Valid N (listwise)	5112				

However, using weighted data (e.g., with the IEA IDB Analyzer), the correct average of the CIL score in Chinese Taipei is calculated actually as 515.27 (see Figure 3.2).

Figure 3.2: Example of weighted analysis using the IEA IDB Analyzer

» Check Analysis Variables - WEIGHTED Statistics

Descriptives

Descriptive Statistics

Country ID - Numeric Code		N	Minimum	Maximum	Mean	Std. Deviation
158	Computer and Information Literacy- 1ST PV	185703	187	789	515.75	86.120
	Computer and Information Literacy- 2ND PV	185703	145	787	515.21	86.011
	Computer and Information Literacy- 3RD PV	185703	180	800	515.18	86.550
	Computer and Information Literacy- 4TH PV	185703	108	792	514.91	87.932
	Computer and Information Literacy- 5TH PV	185703	126	760	515.30	86.464
	Valid N (listwise)	185703				

In this example, the difference between the unweighted and weighted results can be explained by the specific sampling design: the sample is selected disproportionally. For Chinese Taipei, more schools have been selected in two strata (schools in rural and remote areas); these schools have therefore a higher selection probability and corresponding a smaller weight than schools from other strata. The CIL score in these two oversampled strata is lower than in the other ones.

Using weights for single level analysis

The following weights have to be applied when analyzing data from a single level:

- TOTWGTS should be used for student-level analyses (BSG files);
- TOTWGTT should be used for teacher-level analyses (BTG files); and
- TOTWGTC should be used for school-level analyses (BCG files).

We recommend that the IEA IDB Analyzer is used to analyze ICILS 2023 data because this software automatically selects the correct weight variable, depending on the level of the requested analysis. Please note that ICILS 2023 is conceptually a survey of students and teachers and was not designed as a survey of schools. Although it is possible to undertake school-level analyses that generate unbiased results, the sampling precision of the estimates tends to be lower (with larger standard errors and confidence intervals) than it is for analyses at the student or teacher level. Therefore, results concerning school-level data, i.e., data collected from school principals or ICT coordinators, tend to be associated with a high degree of uncertainty.

Using weights for merging files from different levels

Researchers who analyze data simultaneously from different levels need to do this with caution because the process means that different types of data have to be merged. The way different file types need to be combined will depend on the particular research question underlying each analysis. Furthermore, the appropriate choice of weights will depend on the level at which inferences should be made.

- The variable TOTWGTS (the final student weight) has to be used when analyzing student data together with school-level data to answer questions like "which percentages of students share a certain school-level characteristic?" An example would be an analysis of the percentage of students attending a school with a female principal. Chapter 6 of the ICILS 2023 international report (Fraillon, 2024) contains many tables that are a product of this type of analysis.
  The IEA IDB Analyzer makes this type of disaggregated analysis straightforward (see section 4.3). The software merges school-level data with the student data and automatically selects the correct sampling weight variable for the estimation. School information then becomes an attribute of the student, and the user can analyze information based on both data files.
- In the same way, combined teacher and school-level data can be analyzed; here TOTWGTT (the final teacher weight) has to be used as a weighting factor. When performing this kind of analysis, the IEA IDB Analyzer selects also the correct sampling weight variable. For this type of analysis, an example would be the percentage of grade 8 teachers working at a school with a female principal; here school information becomes an attribute of the teachers.
- It is also possible to use weighted aggregates of student or teacher data at the school level for analyses to answer the question which percentage of schools share which characteristic. As the sampling design is not optimized for this kind of analysis, the IEA IDB Analyzer does not support this kind of analysis. Therefore, two additional steps are required prior to undertaking such school-level analyses:
  1. Aggregate student or teacher data by school (using other statistical software tools). Note, when aggregating within-school student data, not all the weighting factors can be disregarded because all students might not share the same within-school weight. Aggregation of within-school student data requires the aggregate to be computed using WGTADJ3S (the student weight adjustment). In case of tracked classes also WGTFAC2S and WGTADJ2S need to be considered, as these could be different for classes in diferent tracks. Aggregation of within-school teacher data requires the aggregate to be computed using WGTFAC3T (the teacher multiplicity adjustment), as this is the only weighting factor that differs between teachers within a given school.
  2. Merge the aggregated data to the school file.

Please note that it is neither possible nor meaningful to directly combine individual student and teacher data files because they constitute two different target populations and are not directly linked to each other. This means that a teacher in a sampled school in the dataset may never have taught a particular student in the same school and, conversely, that surveyed students may never have been exposed to the participating teacher, even though both belong to the same school.

Nevertheless, it is possible to aggregate teacher data at the school level and to operationalize this as an attribute of the students, or to use aggregated student data for an analysis of teacher data. The ICILS 2018 international report (Fraillon et al., 2020) Table 6.13, p. 196, presented one example of such an analysis. For this, teacher responses to questions on professional development participation were aggregated at school level, and these data were then merged to the student data file. Analysis of the generated dataset produced the percentages of students at schools where teachers were participating in professional development focused on using ICT in teaching and learning.

Finally, users should be aware that the proportion of missing values tends to increase when data from different datasets are combined. Because missing data can bias the analysis results, it is important to review possible reductions in the sample size due to missing data before performing the analysis and when interpreting the results. As an example of bias related to missing data, consider the following case: most or all ICILS students with disadvantaged backgrounds did not respond to questions about their respective backgrounds. Any estimation of CIL average scores controlling for these variables would inevitably lead to biased results, because CIL is interrelated with social background, see (Fraillon, 2024) Chapter 6. Multiple imputation methods offer a possible solution for dealing with missing data issues.

Problems with missing data can become particularly problematic for countries with low within-school individual response rates. For example, a national dataset may include some schools that count as participants in the student survey but cannot be considered to have participated in the teacher survey because less than 50 percent of the teachers returned their questionnaire. In such cases, the corresponding schools would be present in the student data file but absent from the teacher data file.

Using weights for multi-level analysis

Working with data at different levels poses some methodological considerations, for details, see Snijders and Bosker (1999). A common approach used for analyzing clustered data is hierarchical (or multilevel) linear modeling (HLM, MLM). Specialized software packages, such as HLM (Raudenbusch et al., 2004), Mplus (Muthén & Muthén, 2012), and MLwiN (Rasbash et al., 2014), provide tools for undertaking this type of analysis. If using multilevel modeling, it is important that users choose the correct set of weights for the different level for analysis.

Mang et al. (2021) provides an in-depth discussion about the use of estimation weights in multi-level regression models. The ICILS 2023 research team supports the described approach. The guidelines below—for choosing the correct weights—are in line with it. As a first step, the levels of the hierarchy need to be defined: Level 1 is always the lowest level of the hierarchy, and for ICILS 2023 this could be typically students or teachers. The cluster constituting level 2 needs to be defined and the cluster weight is calculated by multiplying all design weight(s) and non-response-adjustment(s) resulting from sampling stages that were conducted to select the cluster. This is, if there are multiple sampling stages to select the cluster, they have all to be taken into account.[1] Note that most of the variance in weights occurs at the cluster level, due to the sampling of schools with selection probabilities to their size (PPS).

- If students or teachers constitute level 1 (the within-cluster level), no weight is needed because all units within the cluster share the same selection probability.
- At level 2 (the cluster level), the cluster needed to be defined, which should be driven by the research question. Once defined, the level 2 weight should reflect the probability of the cluster to be in the sample, i.e., its selection probability adjusted for non-response.
  - If the model makes use of school related variables (“IDSCHOOL”), it seems reasonable to use schools at level 2. Such variables might be student or teacher variables aggregated at school level, or variables from the principal questionnaire. In this case a “school weight” should be used. This weight should be computed as the product of the variables WGTFAC1 and WGTADJ1S (WGTFAC1 and WGTADJ1T for analyis of teachers).
  - In case the model makes use of class related variables (“IDCLASS”), it seems reasonable to use class at level 2. Class related variables might be classroom aggregates. In this case, the cluster weight should represent the probability of a class to be selected, adjusted for non-response. This weight should be computed as the product of the variables WGTFAC1, WGTADJ1S, WGTFAC2S, and WGTADJ2S.

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1 Although ICILS 2023 has a three stage sampling design, three-level models cannot be built. Please note that even if two or all classrooms were selected, this would not result in a sufficient sample size to conduct three-level analysis.

Note that it is not appropriate to use the variable TOTWGTC from the school files as level 2 weights: non-response adjustments made to school questionnaire data may differ from school-level non-response adjustments for the student and teacher surveys.

Please note further that due to the change of the within-school sampling design, trend comparability with multilevel modeling analyses is affected: the change to selecting whole (intact) class(es) results in an inherent change to the nature of the school cluster used in multilevel model analyses. If the type of the school cluster is different, results of multilevel modeling analyses (including comparisons of within and between school variances) are not comparable across cycles. This is because classes introduce a second clustering level, or in other words, students from the same classes are more similar than students from different classes within the same school. Therefore the results of multilevel model analyses conducted using student data collected in ICILS 2023 will not be directly comparable to similar analyses conducted in previous cycles.

One important prerequisite for multilevel analysis is that sufficiently large sample sizes at both levels are needed to assure acceptable precision of the estimated model parameters. According to Meinck and Vandenplas (2012), the precision varies considerably for different kinds of model parameters (namely fixed-model parameters versus variances). As a rule of thumb, sample sizes of, at the very least, 10 units at level 1 and 30 units at level 2 can be viewed as the absolute minimum number of units required for multilevel analysis. These sample sizes are important not only for achieving precise parameter estimates but also for obtaining unbiased estimates of the parameters' standard errors.[2] Because the sampling precision differs considerably for different parameters of a multilevel model, analysts must take into account the respective standard errors of coefficients when interpreting the results.

For analysis pertaining to students at level 1, the requirement for sufficiently large samples was met in the majority of schools (classes) in most ICILS 2023 countries (see Table 3.4). However, users should thoroughly review the number of schools (classes) with smaller student samples before conducting such analyses and interpret the results with caution if there are many schools (classes) with small student samples.

2 See Meinck and Vandenplas (2012) for details and an extensive literature review on the topic.

Table 3.4: Number of participating students per cluster (student cluster size)

Country	Level2 = schools				Level2 = classes			
	Min.	Max.	Mean	S.E.	Min.	Max.	Mean	S.E.
Austria	3	53	22.4	10.7	3	29	18.7	5.2
Azerbaijan	4	61	22.2	6.8	4	36	22.0	6.1
Belgium (Flemish)	3	51	24.7	11.7	2	26	16.3	5.5
Bosnia and Herzegovina	5	28	17.9	4.4	4	28	17.5	4.8
Chinese Taipei	8	57	30.2	9.9	3	46	24.8	6.8
Croatia	3	50	19.7	8.9	3	27	17.5	4.6
Cyprus	10	49	33.5	11.5	10	25	19.5	3.4
Czech Republic	8	60	38.9	12.4	8	31	21.9	4.5
Denmark	8	45	21.5	7.3	8	26	19.6	3.4
Finland	8	54	26.9	11.1	1	30	15.7	6.3
France	8	31	24.6	3.3	8	31	24.6	3.3
Germany	6	32	22.8	5.0	6	32	22.8	5.0
Greece	5	26	20.0	3.9	5	26	20.0	3.9
Hungary	5	66	22.5	11.6	2	37	19.6	6.4
Italy	9	48	22.2	8.7	4	28	18.9	3.6
Kazakhstan	3	62	27.6	12.6	1	36	20.3	6.4
Korea, Republic of	13	32	24.5	3.9	13	32	24.5	3.9
Kosovo	1	67	21.9	12.2	1	36	18.6	6.8
Latvia	2	30	18.9	6.2	2	30	18.8	6.3
Luxembourg	11	202	114.7	55.4	1	28	17.4	5.3
Malta	31	117	74.2	25.4	2	26	18.0	4.8
Netherlands, The	10	247	28.0	34.0	7	31	20.1	5.9
Norway (Grade 9)	5	106	29.0	14.8	3	52	21.0	6.2
Oman	7	49	29.1	7.2	1	48	28.5	8.2
Portugal	8	53	22.3	8.8	8	30	20.2	4.3
Romania	4	62	24.0	15.9	1	37	19.0	7.4
Serbia	3	31	20.3	5.3	3	31	20.3	5.3
Slovak Republic	2	30	18.3	5.7	2	30	18.3	5.7
Slovenia	4	31	19.8	4.2	4	28	19.6	4.1
Spain	3	87	23.2	8.3	1	33	21.8	5.5
Sweden	11	54	23.1	8.4	2	35	20.7	4.8
United States	5	37	19.9	5.6	1	30	16.9	7.1
Uruguay	2	30	20.4	5.1	2	30	19.8	5.5
Benchmarking participants								
North Rhine-Westphalia, Germany	6	32	24.6	3.9	6	32	24.6	3.9

If multilevel analyses are done using the entire national sample, the sample size should generally be sufficiently large for conducting this type of analysis. However, if the analysis is undertaken only for subgroups of schools, researchers should ensure that there are no fewer than 30 schools within each subgroup. For the majority of participating countries, conducting multilevel analysis with teacher data is unlikely to result in precise level 1 estimates. The average number of responding teachers per school is around 12.5, see Table 3.5; hence, a significant number of schools have smaller cluster sizes. In this instance, single-level analysis may be preferable in order to obtain more reliable results.

Table 3.5: Number of participating teachers per participating school (teacher cluster size)

Country	Teacher cluster size			
	Minimum	Maximum	Mean	Standard error
Austria	2	18	12.3	3.1
Azerbaijan	7	19	15.0	2.7
Belgium (Flemish)	6	15	11.4	2.4
Bosnia and Herzegovina	7	17	11.9	2.7
Chinese Taipei	7	19	13.4	2.1
Croatia	7	19	12.9	2.3
Cyprus	5	17	11.6	2.7
Czech Republic	5	20	14.8	4.0
Denmark	2	16	7.8	3.3
Finland	8	19	13.5	2.3
France	6	18	12.6	2.7
Germany	5	18	12.8	2.7
Greece	5	19	13.5	2.6
Hungary	4	19	11.2	3.3
Italy	7	19	14.3	1.8
Kazakhstan	8	19	14.6	2.0
Korea, Republic of	8	19	13.7	2.5
Kosovo	4	19	10.9	3.0
Latvia	6	19	12.6	2.8
Luxembourg	5	23	15.5	4.0
Malta	8	15	13.1	2.2
Netherlands, The	7	14	10.0	1.9
Norway (Grade 9)	1	17	9.8	3.4
Oman	4	19	12.2	2.8
Portugal	7	18	12.7	2.2
Romania	5	19	12.9	2.7
Serbia	8	19	14.3	2.2
Slovak Republic	6	16	14.2	1.7
Slovenia	8	19	14.1	2.4
Spain	4	19	12.5	2.7
Sweden	4	17	11.0	2.5
United States	1	19	9.5	5.1
Uruguay	7	18	11.3	2.6
Benchmarking participants				
North Rhine-Westphalia, Germany	6	18	13.8	2.0

Analyses of groups of countries

Thus far, the discussion has focused on analysis of data from one country at a time. However, all the above statements also hold when more than one country is analyzed and researchers should exercise caution when calculating international averages. If an international average is computed using TOTWGTS, TOTWGTT, or TOTWGTC, larger countries will contribute more to this average than smaller countries, which may not be the intention of the researcher. Instead of performing weighted analyses across groups of countries, users must conduct weighted analyses separately for each country and calculate an average of these results afterwards. This is true regardless of whether single-level data, aggregated or disaggregated data, or multi-level data files are used for analysis. Users of the IEA IDB Analyzer do not need to worry about the issue of international averages (called "table averages" there), since the software performs the correct calculations automatically. When calculating an international mean, the IEA IDB Analyzer first calculates national means using the TOTWGT variables and then averages the results over the countries that contribute to the international mean.

3.3 Variance estimation - calculating correct standard errors

Because all statements about any ICILS 2023 population are based upon sample data, they can only be made with a limited degree of certainty. Standard errors reflect the precision of the estimates and should always be reported when analyzing ICILS 2023 data. Also, because the samples were drawn using a stratified complex design, the calculation of standard errors of parameter estimates is not as straightforward as in the case of simple random samples, and standard software packages do not always support this design feature. A variance estimation method that considers the structure of the data is jackknife repeated replication (JRR). The ICILS 2023 international database contains variables that support the implementation of this method. They include the "jackknife zone," the "jackknife replicate," and "replicate weights." For details on the JRR technique used in ICILS 2023, please refer to Chapter 7 of the ICILS 2023 technical report (Fraillon et al., forthcoming). The IEA IDB Analyzer recognizes the data structure of ICILS 2023 automatically and reports correct standard errors for all estimates.

Student-level, teacher-level, and school-level variance estimation variables (or "jackknife variables") are included in the ICILS 2023 international database (Table 3.6, Table 3.7, and Table 3.8). For a description of the variables needed for variance estimation, see Table 2.5.

Table 3.6: Student-level variance estimation variables

Variable	Description	IDB Analyzer file
JKZONES	Jackknife zone - student study	BSG - the student achievement and questionnaire file
JKREPS	Jackknife replicate code - student study	
SRWGT1 to SRWGT75	Student jackknife replicate weights 1 to 75	

Table 3.7: Teacher-level variance estimation variables

Variable	Description	IDB Analyzer file
JKZONET	Jackknife zone - teacher study	BTG - the teacher questionnaire file
JKREPT	Jackknife replicate code - teacher study	
TRWGT1 to TRWGT75	Teacher jackknife replicate weights 1 to 75	

Table 3.8: School-level variance estimation variables

Variable	Description	IDB Analyzer file
JKZONEC	Jackknife zone - school study	BCG - the school and ICT coordinator questionnaire file
JKREPC	Jackknife replicate code - school study	
CRWGT1 to CRWGT75	School jackknife replicate weights 1 to 75	

In other words, when calculations are performed with the IEA IDB Analyzer, the correct variables will be selected automatically.

However, users may want to use specialized software for those types of analysis that go beyond the range of the IEA IDB Analyzer's capabilities. In this case, the jackknife variables must be specified according to the requirements of the software. Usually, "zone" variables have to be specified as "stratum" or "strata" variables, while the "replicate" variables are commonly referred to as "cluster" variables. Frequently, software accepts direct use of the replicate weights. In such cases, the JKZONE and JKREP variables can be ignored. We strongly recommend that data users employ the replicate weights provided for all single-level analysis of ICILS 2023 data.

In case the IEA IDB Analyzer is not used for analysis, the correct variance estimation variables must be applied depending on the type of data:

- For all student level analyses, JKZONES and JKREPS should be used; SRWGT1 to SRWGT75 could be used or needed to be recalculated;
- For all teacher level analyses, JKZONET and JKREPT should be used; TRWGT1 to TRWGT75 could be used or needed to be recalculated; and
- For all school level analyses, JKZONEC and JKREPC should be used; CRWGT1 to CRWGT75 could be used or needed to be recalculated.

Note that even for the same school, the variables at different levels of analysis can differ from each other and thus are not interchangeable. As is the case with weights, researchers should ensure to choose the correct jackknife variables when working with aggregated datasets. The level of analysis (student, teacher, or school) determines which variable to choose.

Importance of using the correct variance estimation method

The data structure must be taken into account when performing analyses, otherwise the analyses are likely to produce incorrect standard errors. Standard errors will be considerably underestimated in most cases, and group differences will become significant even though they are not. The following example illustrates the importance of using the JRR technique when analyzing ICILS data. The ICILS 2023 international report presented country average CIL achievement scores for both females and males (Fraillon, 2024), Figure 6.1, p.158. The difference between average scores for girls in Finland (519) and girls in Portugal (514) was five CIL score points. The standard error has to be used to verify whether the difference is statistically significant. Because the samples compared are independent, equitation 3.4 could be used. With the standard errors of the CIL scores of both countries ($SE_{Finland-girls} = 3.5$; $SE_{Portugal-girls} = 3.6$), the standard error of the difference results in 5.02. The next step is to divide the difference by its standard error to compute the t-value; here t = 1. Accordingly, the CIL average score difference between girls in Portugal and girls in Finland might just be due to chance. But estimating the standard errors of the same CIL scores on the assumption of simple random sampling (by, e.g., using SPSS (IBM Corporation, 2024)) would result in standard errors largely underestimated. If these incorrect standard errors are used for hypothesis testing, the country difference became significant. Failing to apply the weights while still treating samples as simple random samples would lead to underestimation of the standard errors, and the difference would appear insignificant. The effect of underestimating standard errors generally holds for all variables or types of analysis.

Example for variance estimation

Not using the jackknife variables in data analysis will lead to standard errors that do not reflect correctly the uncertainty of point estimates. The following example illustrates the importance of using the JRR technique for research and analysis with ICILS 2023 data.

Researchers may be interested in the average teacher age (variable T_AGE) in Spain. Using plain SPSS or any other statistical software, they find that the average teacher age is about 45.24 years and the standard error seems to be close to 0.13 years (see Figure 3.3).

However, using the JRR technique with the IEA IDB Analyzer, the correct estimate for the standard error is found to be quite larger than indicated by the SPSS analysis (see Figure 3.4).

Figure 3.3: Example of incorrect variance estimation in SPSS

Descriptive Statistics

	N	Mean		Std. Deviation	Variance
	Statistic	Statistic	Std. Error	Statistic	Statistic
Teacher age	6144	45,24	,128	10,056	101,128

Figure 3.4: Example of weighted analysis using the IEA IDB Analyzer

N of Cases	Sum of TOTWGTT	Sum of TOTWGTT (s.e.)	Percent	Percent (s.e.)	T_AGE (Mean)	T_AGE (s.e.)	Std.Dev.	Std.Dev. (s.e.)
6144	125348.30	2558.20	100.00	.00	45.12	.27	9.90	.12

The standard (simple) methods of any statistical software can neither handle weights correctly for sampling variance estimation, nor can they take the clustered data structure into account. This means that not only standard errors but also all analyses that contain significance tests will be incorrect unless specialized software is used.

Estimating sampling variance with jackknife repeated replication

When population parameter μ is estimated, then μ_s is its estimate, assuming all weighted sampled measurements have been used (i.e., applying TOTWGTS for the student population or TOTWGTT for the teacher population). Because all samples in ICILS 2023 are probabilistic, μ_s itself is a random variable, and μ is therefore estimated with a certain degree of precision. To account for this, we use JRR methodology to estimate the sampling variance of μ:

$$SV_\mu = \sum_{i=1}^{75} [\mu_i - \mu_s]^2 \quad (3.1)$$

where 75 refers to the number of jackknife zones, and μ_i is the estimate of μ using the i^{th} set of jackknife replicate weights. The standard error of μ is given by

$$SE_\mu = \sqrt{SV_\mu} \quad (3.2)$$

A particular parameter of interest in ICILS 2023 is the CIL scale. For this particular case, to account for the variability introduced by all plausible values reflecting the construct, the JRR formula to estimate the variance of the construct is given by:

$$SE_{\mu} = (\frac{1}{P}\sum_{j=1}[\sum_{i_1}(\mu_{ij} - \mu_j)^2]) + (\frac{P+1}{P} * \frac{\sum_{j=1}^{p}(\mu_j - \mu)^2}{P-1}) \quad (3.3)$$

where *P* is the number of plausible values (i.e., five in the case of CIL), μ_{ij} is the estimate of μ using the j^{th} plausible value with the i^{th} = set of jackknife replicate weights, and μ_j is the estimate of μ using the j^{th} plausible value with full-sample weights (i.e., TOTWGTS).

Finally, note that in this case, SE_{μ} is the sum of two independent sources of variation. The first term reflects variation on μ due to sampling, while the second reflects variation due to measurement. Once more, please note that the IEA IDB Analyzer applies the above formulas for computing standard error estimates automatically.

Comparing groups and statistical significance testing

Analyzing data by subgroups is common practice in research. However, if the aim is to review statistical differences among subgroups, users will need to proceed cautiously. This is because the sampling design has a direct impact on the standard error of any estimate, as we pointed out on page 26. Even in the case of larger effect sizes, statistically significant differences among subgroups are unlikely if the number of sampled students or teachers within grouping cells is small or if all members of a subgroup belong to only a very small number of schools. Furthermore, the standard error estimate itself is not accurate in these cases. As a rule of thumb, an analysis group should have no fewer than 50 individuals (students or teachers) coming from at least 25 different schools.[3] In developing research questions and designs, we recommend that users evaluate whether the survey and sampling design support the respective research goals.

In this section of this chapter, we consider comparisons of means, percentages, and percentiles. Because comparison of other estimators such as correlation or regression coefficients or standard deviations is not as straightforward, this is not covered in this guide.

Testing for significant differences between group estimates involves the following steps:

1. Estimating the difference between two groups by simply subtracting the two group estimates from each other;
2. Estimating the standard error of the difference and then dividing the difference by its standard error (the result of this division is called the "t-value"); and
3. Comparing the t-value to the t-distribution.

Absolute t-values larger than 1.96 point to significant differences on the 95-percent certainty level ($p < 0.05$). In other words, if the absolute t-value is larger than 1.96, we can, with a probability of 95 percent, predict that the difference is not only present in the sample but also in the population. Note, however, that t-values are no proof of the absence of a difference between two compared subgroups (a mistake commonly made in statistical analysis); instead, the probability of whether or not there is a difference is less than 95 percent. The second step above (computing the standard error of the difference) deserves special attention. The method used to compute this standard error will depend on the composition of the groups to be compared. We can distinguish between three cases.

3 The JRR method measures sampling variance by comparing the variation between paired schools, which makes it important to have enough schools contributing to the computations.

Differences between independent samples

Independent samples consist of sample subgroups that were not part of the same sampling frame. This axiom holds for comparisons across countries or among different explicit strata. The standard error of the difference SE_{dif_ab} and the t-value for two independent groups with their respective group estimates a and b is computed by the IEA IDB Analyzer as

$$SE_{dif\_ab} = \sqrt{SE_a^2 + SE_b^2} \tag{3.4}$$

and

$$t = \frac{(a-b)}{SE_{dif\_ab}} \tag{3.5}$$

Differences between dependent samples

Dependent samples consist of sample subgroups that were part of the same sampling frame. One example is gender groups. Assume that female and male students are sampled as part of the same explicit strata. For example, they attend the same school type (a feature that is relevant if used for explicit stratification), or they share the same teacher and school environment because they attend the same school. The sampling covariance between these subgroups will need to be considered during estimation of the standard errors. Using jackknife replication to estimate the standard error of the difference involves the following formula:

$$SE_{dif\_ab} = \sqrt{[\sum_{i=1}^{75}((a^i - b^i) - (a-b))^2))} \tag{3.6}$$

Here, a and b represent the weighted averages (or percentages) in each of the two subgroups for the fully weighted sample, and a^i and b^i are the weighted averages for the replicate samples.

Where, with respect to ICILS 2023, there are differences in CIL scores, the measurement error also needs to be taken into account using the following formula:

$$SE_{dif\_ab} = \sqrt{\frac{\sum_{p=1}^{P}(\sum_{i=1}^{75}((a_p^i - b_p^i) - (a_p - b_p))^2)}{P} + ((1+\frac{1}{p})\frac{\sum_{p=1}^{P}(a_p - b_p) - ((\overline{a_p}) - (\overline{b_p}))^2}{P-1})} \tag{3.7}$$

Here, a_p and b_p represent the weighted subgroup averages in groups a and b for each of the five plausible values ($P = 5$), a_i and b_i are the subgroup averages within replicate samples for each of the P plausible values, and $(\overline{a_p})$ and $(\overline{b_p})$ are the means of the two weighted subgroup averages across all plausible values.

Obviously, manually computing the standard error estimates of these differences would be tedious. A simpler solution is to model group differences with a regression, an approach which also builds in the covariance term. The IEA IDB Analyzer makes it easy to implement this approach for both variable types; t-values of group differences are part of the output. Section 4.5 of this guide gives a detailed explanation of the implementation of this method. Estimating standard errors of dependent samples by using the method for independent samples risks overestimating the standard error, thereby detecting fewer significant differences than are actually present.

Differences between group and combined-group estimates

Researchers sometimes want to compare a group estimate with a combined estimate where the group of interest also contributes to the combined estimate (of independent groups). A typical example is that of comparing national average scores with the "country average" (an estimate based on data from all participating countries). In this case, the samples to be compared are not independent because the national mean contributes to the estimation of the international mean. The (adjusted) standard error estimate of this difference SE_{dif_ic} can be computed as

$$SE_{dif\_ic} = \frac{\sqrt{((N-1)^2 - 1) - SE_c^2 + \sum_{k=1}^{N}} SE_k^2}{N} \tag{3.8}$$

where SE_c is the standard error for country c and SE_k is the standard error for the k^{th} of the N participating countries (or groups contributing to the combined estimate). Again, because the IEA IDB Analyzer does not offer this operation, it needs to be performed manually.

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Chapter 4:

Analyzing the ICILS 2023 data using the IEA IDB Analyzer

Sebastian Meyer

Overview

This chapter provides an overview of IEA's IDB Analyzer software (IEA, 2024) for analyzing ICILS 2023 data. Designed to work alongside R (R Core Team, 2024), SPSS (IBM Corporation, 2024), or SAS (SAS Institute Inc., 2024), the IEA IDB Analyzer offers a user-friendly interface for seamlessly merging and analyzing the various data file types in the ICILS 2023 international database, and seamlessly takes into account the sampling information and the multiple imputed computer and information literacy (CIL) and computational thinking (CT) scores to produce accurate statistical results.

The chapter includes five example analyses that demonstrate the capabilities of the IEA IDB Analyzer (Version 5.0). These examples highlight how to compute various statistics such as percentages, means, confidence intervals for subgroups, regression coefficients, and the percentages of students meeting the ICILS 2023 international proficiency levels. The examples draw on student, teacher, and school data.

With a basic understanding of the ICILS 2023 international database, users can effectively utilize the IEA IDB Analyzer for statistical analyses. For a comprehensive description of the database, including its structure, file naming conventions, variable details, and supporting documentation, readers are encouraged to refer to Chapter 2.

4.1 About the IEA IDB Analyzer

The IEA IDB Analyzer, developed by IEA Hamburg, serves as an application programming interface (API) for R, SPSS, and SAS, all widely used statistical software programs. It allows users to seamlessly combine data files from IEA's large-scale assessments and perform analyses in R, SPSS, or SAS without needing to write programming code manually. The IEA IDB Analyzer automatically generates R, SPSS, or SAS syntax that incorporates sampling design information for accurate calculation of statistics and their standard errors. Additionally, the syntax appropriately handles plausible values to estimate achievement scores and their standard errors, accounting for both sampling and imputation variance.

The IEA IDB Analyzer consists of three main modules. The Merge Module enables users to create analysis datasets by combining data files of various types (e.g., student and school context data files), across different countries, and selecting subsets of variables for analysis. The Analysis Module offers tools for computing a variety of statistics along with their standard errors. The third module converts SPSS data files to R format, facilitating their use for merging or analysis in R.

R and RStudio, required for working with the IEA IDB Analyzer, can be downloaded for free from r-project.org and posit.co (R Core Team, 2024; RStudio, Inc., 2024). Version 5.0 of the IEA IDB Analyzer requires R version 4.2.0 or later. When executing a script generated by the IEA IDB Analyzer, RStudio will display a list of required packages in the console for installation.

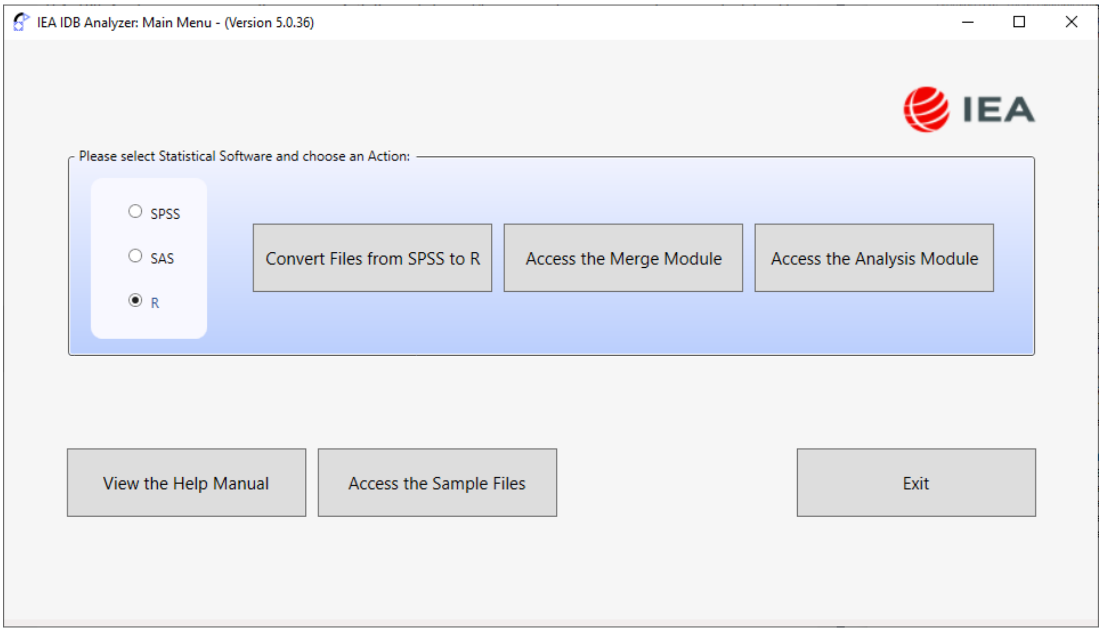
4.2 Installing and launching the IEA IDB Analyzer

The latest release of the IEA IDB Analyzer, version 5.0, can be downloaded from the IEA Data and Tools website. When the application is launched, the main window is displayed, as shown in Figure 4.1, and users are prompted to select their preferred statistical software—R, SPSS, or SAS. While this chapter primarily demonstrates examples using R and RStudio, the interface of the IDB Analyzer remains consistent across all software options. Any differences in outputs between R, SPSS, and SAS are highlighted where relevant.

From the main window, users can choose to **convert SPSS files to R format, access the Merge Module, access the Analysis Module, view the Help Manual, explore Sample Files**, or **Exit** the application.

For comprehensive guidance on the tool's features and capabilities, users are encouraged to refer to the extensive manual available via the Help button within the application.

Figure 4.1: IEA IDB Analyzer main window



4.3 Merging data files with the IEA IDB Analyzer

The IEA IDB Analyzer uses ICILS 2023 data files available from IEA's data repository. The ICILS 2023 data files are disseminated separately by file type (i.e., data source) and by country. In addition to allowing users to combine datasets from more than one country for cross-country analyses, the Merge Module allows for the combination of data from different sources (e.g., student and school) into one R, SPSS, or SAS dataset for subsequent analysis.

The ICILS 2023 design allows several possible combinations of data file types to be merged at different levels (see Table 4.1).

- The school questionnaire file can be merged with every other file type.
- Teacher files can be merged only with themselves (i.e., teacher files from different countries) and with school files. Merging teacher files with student files is not possible. This is due to the study's sample design; the ICILS 2023 teacher sample was drawn by taking all teachers from the students' target grade into account. Because these teachers are usually not just the teachers who teach the sampled students, it is not possible to link the teacher data to student data at the level of individuals. Instead, linking can only be done at the level of the school.
- Student files can be merged only with themselves (i.e., student files from different countries) and with school files, but not with teacher files for the same reasons.

Table 4.1: Possible merging of data between different file types in ICILS 2023

File type	Weight in merged file	Interpretation
Student files of different countries	TOTWGTS	Student characteristics
Teacher files of different countries	TOTWGTT	Teacher characteristics
School files of different countries	TOTWGTC	School characteristics
Student file and school file of a country	TOTWGTS	Student characteristics; school characteristics as properties of students
Teacher file and school file of a country	TOTWGTT	Teacher characteristics; school characteristics as properties of teachers

Merging files from different levels has implications for analysis of the data: when data files from different levels are merged, the weights retained in the merged file will depend on the particular levels that were merged. This situation also has implications for interpretation of the results. As an example, when school and teacher files are merged, the teacher becomes the reference (unit of analysis), and the computed statistics are interpreted as applying to "teachers who teach in schools with characteristic X" (see Table 4.1). Please note that merging data from different levels may result in larger amounts of missing data if more than one variable is involved in the analysis. For example, suppose teacher files and school files are merged. If the analysis variables from both teachers and school principals (or school ICT-coordinators) are used, the number of missing responses are likely to increase because the missing data from teachers and from school principals have been combined.

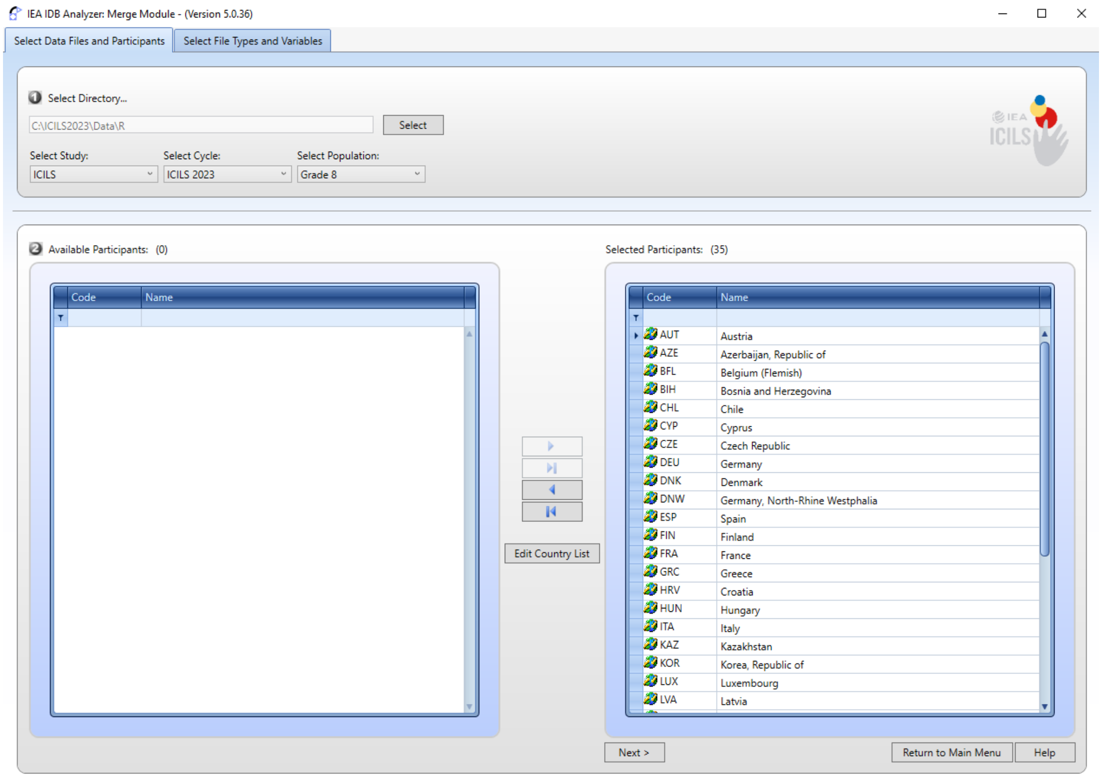
Before doing any statistical analysis with the ICILS 2023 international database, users should download and copy the contents of the international database either on their computer or on a server. All files should be within a single folder. For the examples in this chapter, all data files are copied within the folder `C:\ICILS2023\Data\R`.

Merging data from different countries

The following steps will create a data file with data from multiple countries:

1. Start the IEA IDB Analyzer and click the **Merge Module** button.
2. Under the **Select Data Files and Participants** tab and in the **Select Directory** field, browse to the folder where all data files are located. All files must be in the same folder. For example, in Figure 4.2, all R data files are located in the folder `C:\ICILS2023\Data\R`. The program will automatically recognize and complete the **Select Study, Select Cycle**, and **Select Population** fields and list all countries available in this folder as possible to merge. If the folder contains data from more than one IEA study (e.g., ICILS, TIMSS) or cycle (e.g., ICILS 2023, ICILS 2018), users should select the desired combination.

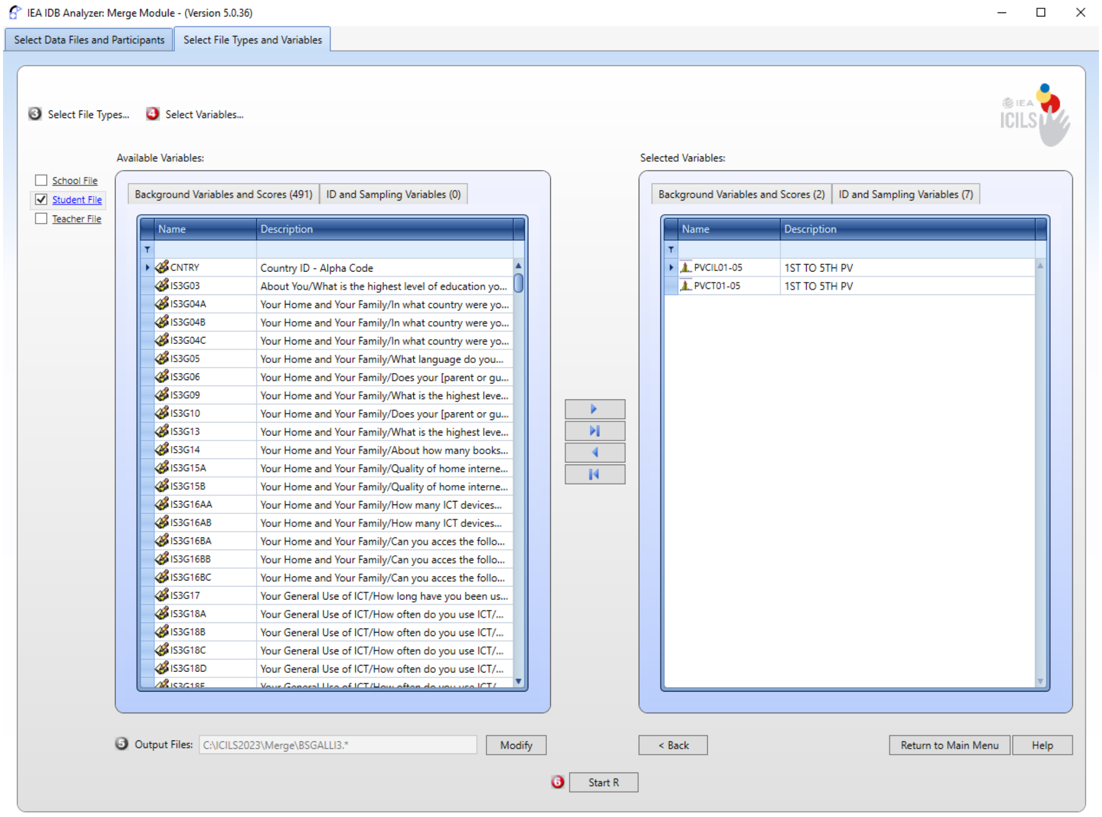
Figure 4.2: IEA IDB Analyzer Merge Module – Select Data Files and Participants



3. Click a country of interest from the **Available Participants** list and click the **right arrow**(▶) button to move it to the **Selected Participants** panel. Individual countries can be moved directly to the **Selected Participants** panel by double-clicking on the row. To select multiple countries, hold the **Ctrl** key on the keyboard when clicking countries. Click the **tab-right arrow** (▶|) button to move all countries to the **Selected Participants** panel. In Figure 4.2, all ICILS 2023 participants are selected.

4. Click the **Next >** button to proceed to the next step. The software will open the **Select File Types and Variables** tab of the Merge Module, as shown in Figure 4.3, to select the file types and the variables to be included in the merged data file.

Figure 4.3: IEA IDB Analyzer Merge Module – Select File Types and Variables



5. Select the files for merging by checking the appropriate boxes to the left of the window. For example, in Figure 4.3, the box next to **Student File** is checked, indicating the ICILS 2023 student data files are selected.

6. Select the variables of interest from the **Available Variables** list in the left panel. The codebook files (described in Chapter 2 of this user guide) as well as Supplement 1 of this user guide provide the variable names for storing the data from all questions in the ICILS 2023 Context Questionnaires. Variables are selected by clicking on them, then moving them to the **Selected Variables** list by clicking the **right arrow** (▶) button. Clicking the **tab-right arrow** (▶|) button selects and moves all variables to the **Selected Variables** list. Note that there are two tabs under the **Selected Variables** list: **Background Variables and Scores** and **ID and Sampling Variables**. All achievement scores and all identification, tracking, and sampling variables are selected by default.

7. Specify the desired name for the merged data file and the folder where it will be stored in the **Output Files** field by clicking the **Define** (or **Modify**) button. The IEA IDB Analyzer will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the merge. In the example shown in Figure 4.3, the R script file BSGALLIr.R and the merged data file BSGALLI3.Rdata both will be created and stored in the folder `C:\ICILS2023\Merge`. The merged data file will contain all the variables listed in the **Selected Variables** panel on the right.

8. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

Once the statistical program of choice has completed its execution, it is important to check the software output window or log file for possible warnings. If warnings appear, they should be examined carefully, as they might indicate that the merge process was not performed properly and that the resulting merged data file might not be as expected.[4]

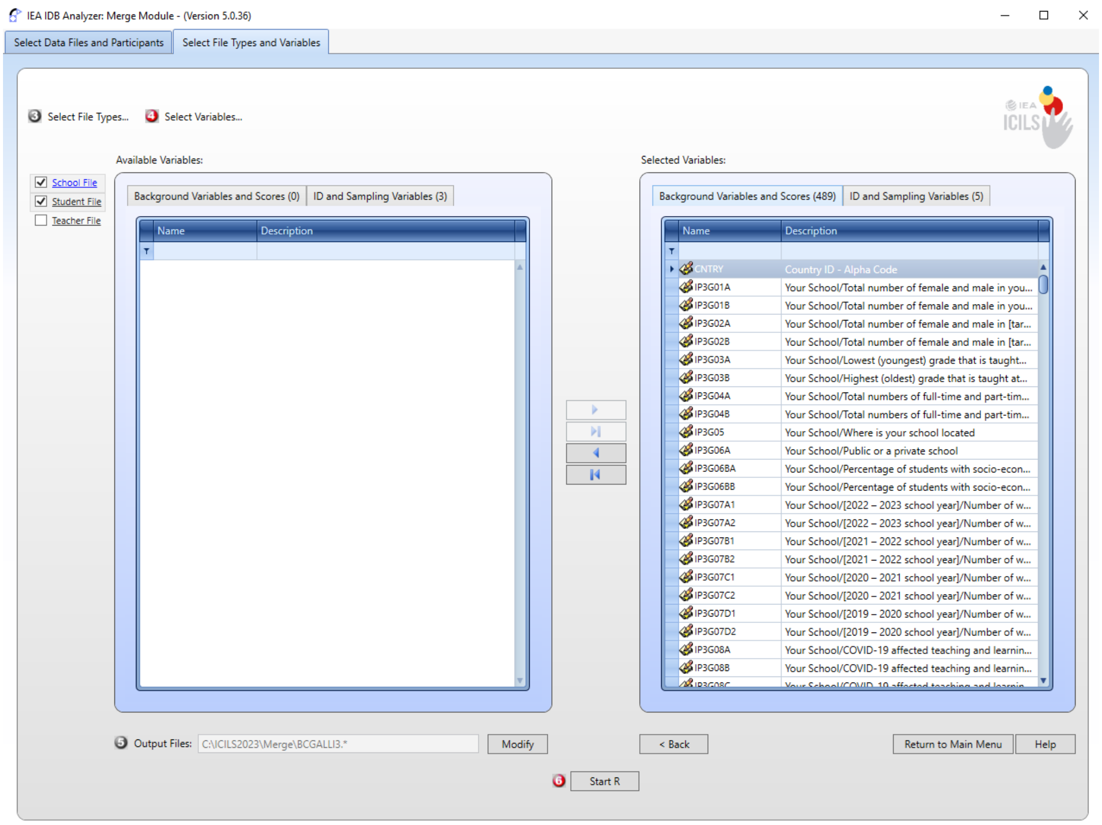
Merging student and school data files

Because ICILS 2023 includes representative samples of schools, it is possible to compute appropriate statistics with schools as units of analysis. However, the school samples were designed to optimize the student samples and the student-level results. For this reason, it is preferable to analyze school context variables as attributes of the students, rather than as elements in their own right. Therefore, school context data is best analyzed by linking students to their respective schools.

To merge the student and school data files, select both the student and school file types in the **Select File Types and Variables** tab of the IEA IDB Analyzer Merge Module. This is an important step to ensure the student weights and achievement variables are included for analyses (see Figure 4.4). The variables of interest need to be selected separately for both file types, as follows:

1. Click the checkbox next to the student file type so that it appears checked and highlighted. **The Background Variables and Scores** listed in the left-hand **Available Variables** panel will list all variables from the student data files. This is an important step to ensure the proper weights and achievement variables are included for analyses.

Figure 4.4: IEA IDB Analyzer Merge Module – Select File Types and Variables for merging student and school data



4 For more information on how to use the IEA IDB Analyzer, and for troubleshooting, users should consult the Help manual.

2. By default, the student CIL and CT plausible values, identification, and tracking variables are added to the data file. Select any additional student variables of interest from the left panel and click the **right arrow**(▶) button to move these variables to the **Selected Variables** panel on the right. Click the **tab-right arrow** (▶|) button to select all available variables.

3. Click the checkbox next to the School file type and select the variables of interest from the **Background Variables and Scores** panel on the left in the same manner as in steps 1 and 2, as shown in Figure 4.4.

4. Specify the desired name for the merged data file and the folder where it will be stored in the **Output Files** field by clicking the **Define/Modify** button. The IEA IDB Analyzer also will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the merge. The merged data file will contain all the variables listed in the **Selected Variables** panel on the right.

5. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

Merging teacher and school data files

Merging the teacher and school data files follows the same procedure as merging the school and student data files. School-level data will be disaggregated to the teacher level by adding the respective school-level variables to each teacher record. To merge teacher questionnaire and school questionnaire data files, perform steps 1 to 4 as described in the previous section. Then, simply select both file types in the second window of the IEA IDB Analyzer Merge Module. The variables of interest need to be selected separately for both file types, as follows:

1. Click the checkbox next to the teacher file type so that it appears checked and highlighted. **The Background Variables and Scores** listed in the left-hand **Available Variables** panel will list all variables from the teacher data files. This is an important step to ensure the proper weights and achievement variables are included for analyses.

2. Select any additional teacher variables of interest from the left panel and click the **right arrow**(▶) button to move these variables to the **Selected Variables** panel on the right. Click the **tab-right arrow** (▶|) button to select all available variables.

3. Click the checkbox next to the School file type and select the variables of interest from the **Background Variables and Scores** panel on the left in the same manner as in steps 1 and 2.

4. Specify the desired name for the merged data file and the folder where it will be stored in the **Output Files** field by clicking the **Define/Modify** button. The IEA IDB Analyzer also will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the merge. The merged data file will contain all the variables listed in the **Selected Variables** panel on the right.

5. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

Merged data files for the User Guide examples

To conduct the analysis examples presented in this chapter, three merged data files were created following the instructions provided above. Because the examples presented in this user guide are all about ICILS 2023, merged data files were produced with all countries that participated in ICILS 2023.

A full list of countries and their participation in ICILS 2023 is provided in Chapter 2. The following two merged data files were created with all available context variables and achievement scores selected:

- BSGALLLI3 - Merged student data files with all variables selected for all countries
- BCGALLLI3 - Merged school and student data files with all variables selected for all countries
- BTGALLLI3 - Merged school and teacher data files with all variables selected for all countries

4.4 Conducting analyses with the IEA IDB Analyzer

The IEA IDB Analyzer can perform statistical analyses on any files created using the **Merge Module**. The **Analysis Module** of the IEA IDB Analyzer allows users to specify the type of analysis and select variables from a merged data file as analysis variables. To conduct analyses using plausible values (PVs) for CIL and/or CT, after selecting a **Statistic Type**, users should select the **Use PVs** option from the **Plausible Value Option** drop-down menu.

All statistical procedures offered in the Analysis Module of the IEA IDB Analyzer make appropriate use of sampling weights, and standard errors are computed using the jackknife repeated replication (JRR) method. When achievement scores are used, the analyses are performed five times (once for each plausible value) and the results are aggregated to produce accurate estimates of achievement and standard errors that incorporate both sampling and imputation errors.

When conducting analyses using contextual variables, users should check whether countries have any missing data on the context variables. High levels of missing data could bias results. Similarly, achievement estimates can be unreliable if based on small groups of students.

Statistical procedures in the IEA IDB Analyzer

The following statistical procedures are available in the Analysis Module of the IEA IDB Analyzer.

Percentages and Means

Compute percentages, means, and standard deviations for selected analysis variables by subgroups defined by grouping variable(s). Plausible values can be included as analysis variables. This procedure is used in Examples 1, 2, and 6 of this chapter.

Percentages Only

Compute percentages by subgroups defined by grouping variable(s). This procedure is used in Example 5 of this chapter.

Linear Regression

Compute linear regression coefficients for selected independent variables to predict a continuous dependent variable by subgroups defined by grouping variable(s). Plausible values can be included as dependent or independent variables. This procedure is used in Example 3 of this chapter.

Logistic Regression

Compute logistic regression coefficients for selected independent variables to predict a dichotomous dependent variable by subgroups defined by grouping variable(s). Plausible values can be included as dependent or independent variables. When used as a dependent variable, plausible values will be dichotomized using a specified cutpoint, such as one of the ICILS 2023 proficiency levels. This procedure is available only for use with SPSS and SAS in Version 5 of the IEA IDB Analyzer.

Correlations

Compute means, standard deviations, and correlation coefficients for selected analysis variables by subgroups defined by grouping variable(s). Plausible values can be included as analysis variables.

Benchmarks

Compute percentages of students meeting a set of user-specified achievement benchmarks, in particular the ICILS 2023 international scale levels, by subgroups defined by grouping variable(s). This procedure is used in Example 4 of this chapter.

Percentiles
Compute the score points that separate a given proportion of the distribution of a continuous analysis variable by subgroups defined by the grouping variable(s). Plausible values can be included as analysis variables.

Definitions of Analysis Variables in the IEA IDB Analyzer
The various variables required to conduct an analysis are input into specific variable fields according to their purpose. All available features of the IEA IDB Analyzer are described extensively in its Help manual.

Grouping Variables
This is a list of variables to define subgroups of interest. The list must consist of at least one grouping variable. By default, the IEA IDB Analyzer includes the variable IDCNTRY used to distinguish the participating countries. Additional variables can be selected from the available list. If the **Exclude Missing From Analysis** option is checked, only cases that have non-missing values in the grouping variables will be used in the analysis. If it is not checked, missing values become reporting categories.

Analysis Variables
This is a list of variables for which means, percentages, correlations, or percentiles are to be computed. Usually, more than one analysis variable can be selected. To compute statistics based on achievement scores, after choosing the **Statistic Type**, it is necessary to select the **Use PVs** option in the **Plausible Value Option** drop-down menu and select the achievement scores of interest in the **Plausible Values** field.

Plausible Values (PVs)
This section is used to identify the set of plausible values to be used when achievement scores are the analysis variable for computing statistics. After choosing the **Statistic Type**, select the **Use PVs** option in the **Plausible Value Option** drop-down menu before specifying the achievement scores of interest in the **Plausible Values** field.

Independent Variables
This is a list of variables to be treated as independent variables for a linear or logistic regression analysis. More than one independent variable can be selected. Categorical variables and continuous variables can be specified as independent variables. When specifying categorical variables as independent variables, they can be treated either as "effect coding" or "dummy coding" using the **Contrast** drop-down menu (dummy coding is used in Example 3). Achievement scores also can be included as an independent variable. To specify achievement scores as an independent variable, it is necessary to select the **Use PVs** option in the **Plausible Value Option** drop-down menu and select the achievement scores of interest in the **Plausible Values** field.

Dependent Variable
This is the variable to be used as the dependent variable when a linear or logistic regression analysis is specified. Only one dependent variable can be listed and can be either a context variable or achievement variables (PVs). To use achievement as the dependent variable, select the **Use PVs** option in the **Plausible Value Option** drop-down menu, click on the **Plausible Values** radio button in the **Dependent Variable** section, and select the achievement scale of interest in the **Plausible Values** field.

Achievement Scale Levels (Benchmarks)
These are the values that will be used as cutpoints on an achievement scale, selected in the **Plausible Values** section, for computing the percentages of students meeting the specified scale levels. Multiple cutpoints can be specified, each separated by a blank space. A drop-down menu is available to select the four ICILS international scale levels.

Percentiles
These are the percentiles that will be calculated from the distribution of a continuous analysis variable selected in the **Analysis Variables** section. Achievement PVs can be selected as analysis variables. Select the **Use PVs** option in the **Plausible Value Option** drop-down menu and select the achievement scale of interest in the **Plausible Values** field. Multiple percentiles can be specified, each separated by a blank space.

Weight Variable
This is the sampling weight variable that will be used in the analysis. The IEA IDB Analyzer automatically selects the appropriate weight variable for analysis based on the file types included in the merged data file.

4.5 Performing analyses with student-level variables

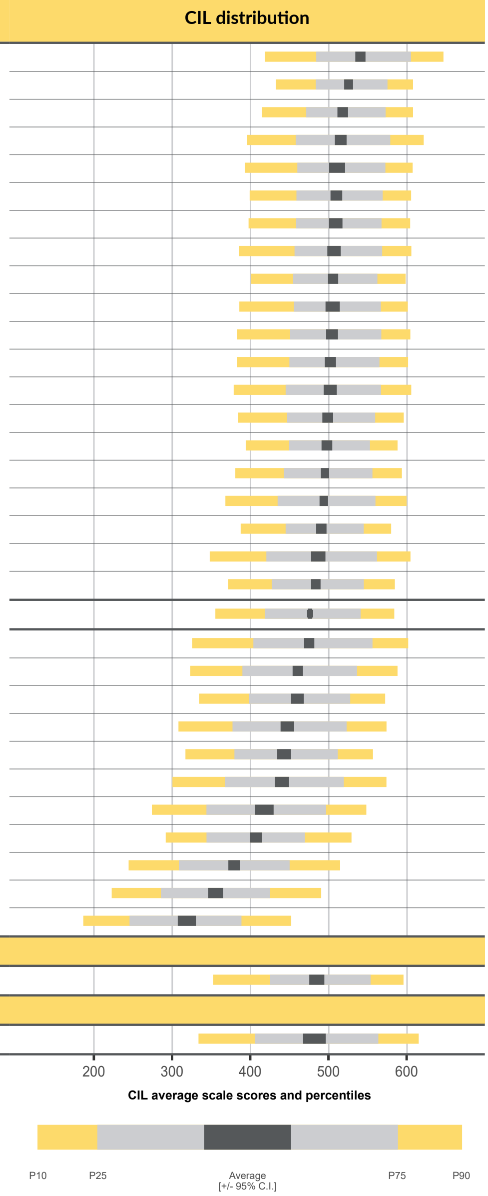
Many analyses of the ICILS 2023 data can be undertaken using student-level data only. This section presents examples of analyses used to produce tables for the ICILS 2023 international report (Fraillon, 2024).

The examples use the merged ICILS 2023 student context data file BSGALLLI3 described earlier under Merging Data Files with the IEA IDB Analyzer, including all countries and all available variables. Example 1 computes average achievement by country, whereas Example 2 computes national average achievement by gender. Example 3 expands on the second example by performing a test of statistical significance on the gender difference using linear regression. Lastly, Example 4 computes the percentages of students reaching each of the ICILS 2023 international proficiency levels.

Analysis of average CIL
In our first example, we replicate the average CIL scale scores presented in the ICILS 2023 international report (Fraillon, 2024). The corresponding table from the international report is shown in Table 4.2.

Table 4.2: Country averages and distribution for CIL

Country	Average CIL scale score		
[†] Korea, Republic of	540	(2.5)	▲
[1] Czech Republic	525	(2.1)	▲
[†1] Denmark	518	(2.7)	▲
Chinese Taipei	515	(3.0)	▲
[†] Belgium (Flemish)	511	(4.4)	▲
[1] Portugal	510	(3.0)	▲
[1] Latvia	509	(3.6)	▲
Finland	507	(3.6)	▲
[1] Austria	506	(2.5)	▲
Hungary	505	(3.8)	▲
[1] Sweden	504	(3.0)	▲
[1] Norway (Grade 9)	502	(2.9)	▲
Germany	502	(3.5)	▲
Slovak Republic	499	(2.7)	▲
France	498	(2.7)	▲
[1] Spain	495	(1.9)	▲
Luxembourg	494	(2.0)	▲
Italy	491	(2.6)	▲
[1] Croatia	487	(3.9)	▲
[1] Slovenia	483	(2.3)	▲
ICILS 2023 average	476	(0.6)	
Malta	475	(2.5)	
Cyprus	460	(2.6)	▽
Greece	460	(3.3)	▽
[†] Uruguay	447	(3.6)	▽
[1] Serbia	443	(3.7)	▽
[3] Bosnia and Herzegovina	440	(3.8)	▽
[†12] Romania	418	(5.3)	▽
[1] Kazakhstan	407	(3.1)	▽
Oman	379	(3.0)	▽
[1] Kosovo	356	(4.1)	▽
Azerbaijan	319	(5.1)	▽
Benchmarking participant			
[1] North Rhine-W. (Germany)	485	(4.1)	▲
Country not meeting sample participation requirements			
[‡] United States	482	(6.6)	



▲ Average significantly higher than ICILS 2023 average.

▽ Average significantly lower than ICILS 2023 average.

Notes: Standard error appear in parentheses (). Because of rounding some results may appear inconsistent. ICILS 2023 average is based on all non-benchmarking participants that met sampling participation requirements except Romania. Countries are ranked in descending order of the average CIL scale score.

[†] Met guidelines for sampling participation rates only after replacement schools were included.

[‡] Did not meet guideline for sampling participation rate, but achieved at least 50% overall sampling participation rate.

[1] National defined population covers 90% to 95% of the national target population. See Appendix A for further information.

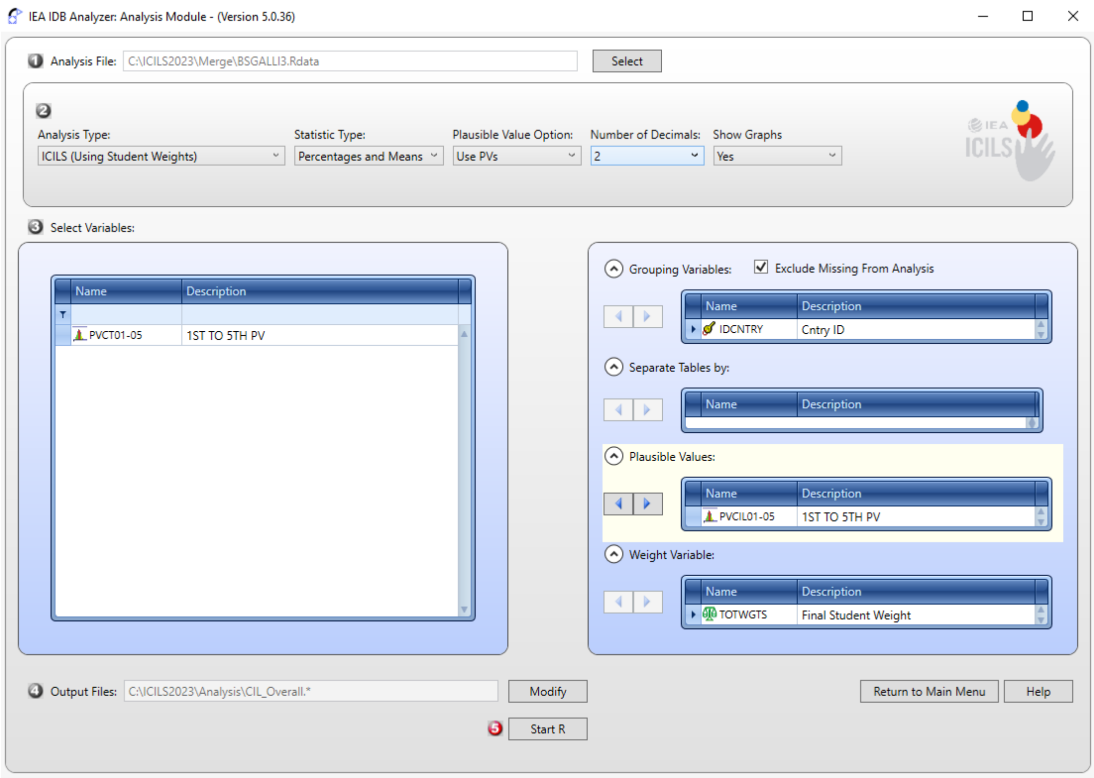
[2] Country surveyed target grade in the first half of the school year.

[3] National defined population covers 61% of the national target population.

This analysis uses student-level data (only) and is based on plausible values. Thus, users should make sure the PVs are included in the file created using the merge module. The BSGALLI3 file, which will be used for this analysis, fulfills these requirements. The **Percentages and Means** statistic type with the **Use PVs** option selected will compute percentages and average achievement scores based on plausible values and their respective standard errors.

The completed Analysis Module for this example is shown in Figure 4.5.

Figure 4.5: IEA IDB Analyzer setup for example student-level analysis with achievement scores



1. Open the **Analysis Module** of the IEA IDB Analyzer. Select the merged data file BSGALLI3 as the **Analysis File** by clicking the **Select** button.
2. Select **ICILS (Using Student Weights)** as the **Analysis Type**.
3. Select **Percentages and Means** as the **Statistic Type**.
4. Select **Use PVs** as the **Plausible Value Option**.
5. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
6. The default value selected in the **Show Graphs** menu is **Yes**. For this analysis, selecting **Yes** will produce two graphs in the output file: one graph showing average achievement by country (bar graph in R and SPSS; line graph in SAS), and one bar graph for the weighted percentage of the total students in each country.
7. The IDB Analyzer automatically selects the variable IDCNTRY for the **Grouping Variables**. No additional grouping variables are needed for this analysis. The IEA IDB Analyzer automatically checks the **Exclude Missing From Analysis**, which excludes cases with missing values on the grouping variables from the analysis. Since the IDCNTRY variable does not contain any missing values, checking this box makes no difference for this analysis.
8. The **Separate Tables** by field should be empty for this analysis. This field is used to separately analyze several grouping variables or several continuous dependent (non-achievement) variables. See the IEA IDB Analyzer Help manual for more information.
9. Specify the achievement scores to be used for the analysis by first clicking the **Plausible Values** field to activate it. Then, select PVCIL01–05 from the list of available variables in the left panel and move it to the right **Plausible Values** field by clicking the **right arrow**(▶) button.

10. The **Weight Variable** is selected automatically by the software; TOTWGTS is selected by default because this example analysis uses student data.

11. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define** (or **Modify**) button in the **Output Files** field. The IEA IDB Analyzer also will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the analysis. In Figure 4.5, the syntax file CIL_Overall.R and the output files with the same name will be created and stored in the `C:\ICILS2023\Analysis` folder.

12. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

The IDB Analyzer produces and saves the results output in three file formats within the same folder specified in step 11 – an HTML output file (or output in SPSS/SAS), R data file (*.Rdata), and Microsoft Excel Worksheet (*.xlsx). The output files are named using the same name specified for the syntax file in step 11. The HTML reports produced by R are named with the suffix "PVCIL" indicating the outcome variable. Graphs are included only in the HTML (or SPSS/SAS) output files.

Figure 4.6 displays the results in the R output displaying the first ten countries. The results are presented in the "Report" section of the HTML output produced by R.

Figure 4.6: Output for example student-level analysis with CIL achievement scores

Report

Analysis for PVCIL by IDCNTRY

Cntry ID	N of Cases	Sum of TOTWGTS	Sum of TOTWGTS (s.e.)	Percent	Percent (s.e.)	PVCIL (Mean)	PVCIL (s.e.)	Confidence Interval (95)	Std.Dev.	Std.Dev. (s.e.)	Percent Missing	Number of Variance Strata
Azerbaijan, Republic of	3634	153443	5536.07	1.68	0.06	318.65	5.10	309 - 329	100.34	3.20	0.00	75
Austria	3448	76209	1590.14	0.83	0.02	505.58	2.52	501 - 511	76.34	1.78	0.00	75
Bosnia and Herzegovina	1877	17708	396.81	0.19	0.00	440.28	3.79	433 - 448	104.42	2.71	0.00	57
Chile	3216	255575	5868.03	2.79	0.07	429.22	3.86	422 - 437	97.28	1.80	0.00	65
Chinese Taipei	5112	185703	2094.29	2.03	0.03	515.27	3.02	509 - 521	86.62	1.86	0.00	75
Croatia	2911	37753	1277.86	0.41	0.01	486.60	3.86	479 - 494	99.33	2.43	0.00	74
Cyprus	3182	9568	99.47	0.10	0.00	460.42	2.58	455 - 465	101.14	1.86	0.00	75
Czech Republic	8169	114257	1952.97	1.25	0.03	525.39	2.10	521 - 529	68.55	1.66	0.00	75
Denmark	3038	61116	1421.53	0.67	0.02	517.86	2.67	513 - 523	75.90	1.99	0.00	71
Finland	4249	58207	1062.81	0.64	0.01	506.69	3.56	500 - 514	85.39	2.19	0.00	75

Each country's results are presented on a single line, with countries ordered sequentially according to their numeric ISO code (see Chapter 2). Results for "Table Average" may be produced (not shown), based on all countries included in the data file. The countries are identified in the first column (Cntry

ID) and the second column reports the number of valid cases (N of Cases). The third column reports the sum of weights of the sampled students (Sum of TOTWGTS), indicating the estimated total 8th grade population. The fourth column is the standard error of the sum of weights (Sum of TOTWGTS (s.e.)). The next two columns report the weighted percentage of students by the grouping variable (Percent), which for this analysis is the percentage of all students in each country out of the total, and its standard error (Percent (s.e.)). The next two columns report the estimated average for the outcome variable, in this case CIL scores (PVCIL (Mean)) and its standard error (PVCIL (s.e.)) ("mnpv" and "mnpv"_se in Excel). The subsequent column reports the 95 percent confidence intervals around the mean. The standard deviation of the achievement scores (Std.Dev.) and its standard error (Std.Dev. (s.e.)) are reported in the next two columns. The last two columns report the percentage of cases with missing data (Percent Missing) and the number of jackknife zones used for computing standard errors (Number of Variance Strata), respectively.

Among the listed 10 ICILS 2023 countries shown in the output in Figure 4.6, the Czech Republic had the highest average achievement. As shown in the eighth line of the table, the Czech Republic had valid data for 8,169 students, and these sampled students represented a population of about 114,257 students, indicated by the sum of the weights. The average CIL score in the Czech Republic was 525.39 (standard error of 2.10) and its confidence interval with 521 as the lower and 529 as the upper boundary. The standard deviation was 68.55 (standard error of 1.66).

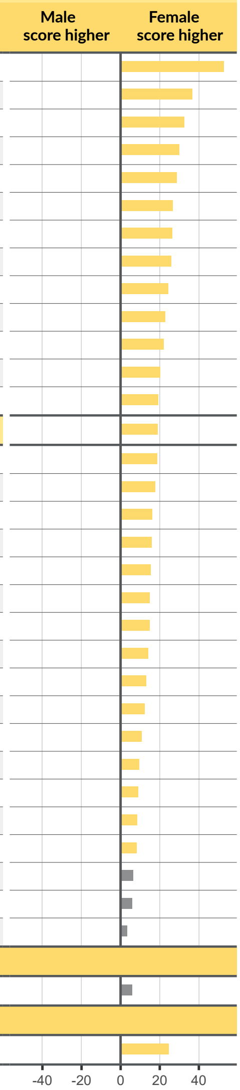
Analysis of average CIL by gender

In our second example, we replicate another set of results presented in the ICILS 2023 international report (Fraillon, 2024). In this case, the example investigates the relationship between students' gender and CIL, the latter being represented by a set of five plausible values. Since the results are based on plausible values, these must be included when a user creates the file using the merge module, to indicate that the analysis will make use of CIL achievement scores when the user specifies the analysis type.

The corresponding table from the international report is shown in Table 4.3.

Table 4.3: Country averages and distribution for CIL by gender

Country	Male		Female		Difference CIL score averages
	Percentage	Average score	Percentage	Average score	Female - Male
Oman	52 (1.5)	354 (4.9)	48 (1.5)	406 (3.2)	**53** (5.9)
[1] Croatia	51 (0.8)	469 (4.7)	49 (0.8)	505 (4.6)	**37** (5.1)
Malta	49 (0.9)	460 (3.6)	51 (0.9)	493 (3.1)	**32** (4.2)
Chinese Taipei	54 (0.8)	501 (3.8)	46 (0.8)	531 (2.9)	**30** (3.3)
† Korea, Republic of	51 (1.0)	527 (3.1)	49 (1.0)	556 (3.1)	**29** (3.9)
[1] Slovenia	51 (0.7)	471 (2.7)	49 (0.7)	497 (2.8)	**27** (2.9)
Cyprus	49 (0.7)	447 (3.7)	51 (0.7)	473 (2.9)	**26** (4.3)
[1] Norway (Grade 9)	51 (0.8)	490 (3.7)	49 (0.8)	516 (3.0)	**26** (3.7)
Finland	49 (1.0)	494 (4.5)	51 (1.0)	519 (3.5)	**24** (3.8)
†[1] Denmark	51 (1.0)	508 (3.6)	49 (1.0)	531 (2.6)	**23** (3.6)
[1] Latvia	50 (1.1)	498 (4.4)	50 (1.1)	520 (3.7)	**22** (3.7)
Azerbaijan	53 (0.9)	309 (5.6)	47 (0.9)	329 (5.4)	**20** (4.4)
Luxembourg	51 (0.7)	484 (2.5)	49 (0.7)	504 (2.5)	**19** (3.1)
ICILS 2023 average	51 (0.2)	467 (0.7)	49 (0.2)	486 (0.6)	**19** (0.7)
[1] Spain	52 (0.8)	486 (2.4)	48 (0.8)	505 (2.0)	**19** (2.5)
Italy	51 (0.9)	482 (3.1)	49 (0.9)	500 (2.7)	**18** (2.6)
† Belgium (Flemish)	53 (2.0)	504 (5.1)	47 (2.0)	520 (5.2)	**16** (4.9)
[1] Sweden	52 (1.2)	497 (3.7)	48 (1.2)	513 (3.4)	**16** (4.0)
[1] Austria	49 (1.4)	498 (3.2)	51 (1.4)	513 (2.8)	**15** (3.3)
Greece	51 (1.0)	453 (4.2)	49 (1.0)	468 (3.5)	**15** (3.9)
[1] Kazakhstan	51 (0.7)	400 (3.7)	49 (0.7)	415 (3.3)	**15** (3.3)
[1] Kosovo	52 (1.0)	349 (4.3)	48 (1.0)	363 (4.9)	**14** (4.5)
[3] Bosnia and Herzegovina	52 (1.3)	434 (4.8)	48 (1.3)	447 (4.6)	**13** (5.7)
†[1,2] Romania	50 (1.2)	412 (5.8)	50 (1.2)	424 (6.4)	**12** (5.9)
[1] Serbia	52 (1.0)	438 (4.2)	48 (1.0)	449 (4.1)	**11** (4.0)
Germany	51 (1.1)	497 (4.1)	49 (1.1)	507 (3.7)	**10** (3.7)
[1] Portugal	50 (1.1)	505 (3.5)	50 (1.1)	514 (3.6)	**9** (3.5)
Slovak Republic	50 (1.0)	494 (3.1)	50 (1.0)	503 (3.0)	**8** (2.8)
France	50 (0.7)	494 (3.1)	50 (0.7)	502 (3.0)	**8** (2.9)
Hungary	50 (0.9)	502 (4.3)	50 (0.9)	508 (4.2)	6 (3.7)
† Uruguay	51 (0.8)	444 (4.4)	49 (0.8)	450 (4.0)	6 (4.2)
[1] Czech Republic	51 (0.7)	524 (2.1)	49 (0.7)	527 (2.4)	3 (1.8)
Benchmarking participant					
[1] North Rhine-W. (Germany)	53 (1.0)	482 (6.3)	47 (1.0)	488 (3.7)	6 (6.5)
Country not meeting sample participation requirements					
‡ United States	49 (1.5)	468 (7.5)	51 (1.5)	493 (6.8)	**25** (6.0)

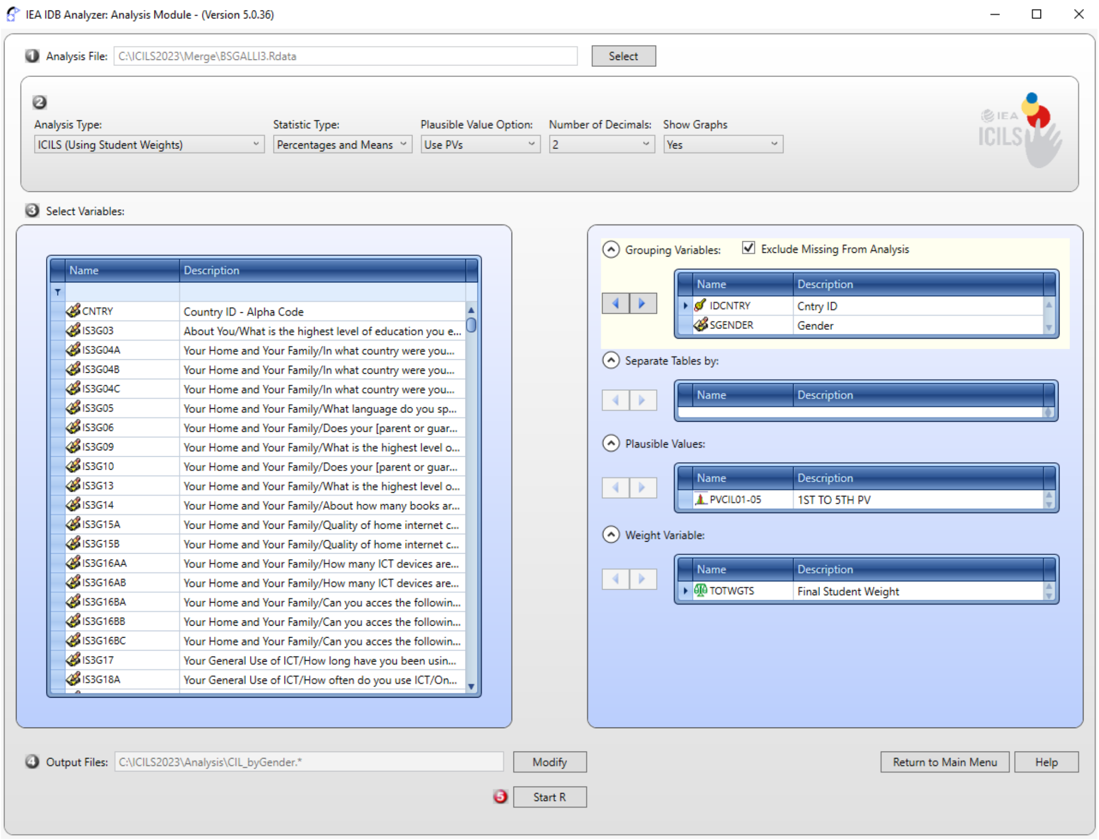


Difference between groups statistically significant (p<0.05)
Difference between groups not statistically significant

Notes: Standard error appear in parentheses (). Because of rounding some results may appear inconsistent. Statistically significant differences (p<0.05) between subgroups are shown in **Bold**. ICILS 2023 average is based on all non-benchmarking participants that met sampling participation requirements except Romania. Countries are ranked in descending order of the CIL score difference between groups.
† Met guidelines for sampling participation rates only after replacement schools were included.
‡ Did not meet guideline for sampling participation rate, but achieved at least 50% overall sampling participation rate.
[1] National defined population covers 90% to 95% of the national target population. See Appendix A for further information.
[2] Country surveyed target grade in the first half of the school year.
[3] National defined population covers 61% of the national target population.

The codebooks reveal that the variable SGENDER in the student data files contains categorical information on the gender of the student. The Percentages and Means analysis type with the Use PVs option activated computes percentages and mean CIL scores based on plausible values and their respective standard errors. The IEA IDB Analyzer enables the user to replicate the analysis of gender differences in CIL scores. After opening the analysis module and selecting the BSGALLI3.Rdata data file, the steps in the IEA IDB Analyzer are as follows (Figure 4.7 illustrates the appearance of the analysis module with the settings for this example analysis entered correctly):

Figure 4.7: IEA IDB Analyzer setup for example student-level analysis with CIL achievement scores by gender



1. Open the **Analysis Module** of the IEA IDB Analyzer.
2. Select the merged data file BSGALLLI3 as the **Analysis File** by clicking the **Select** button.
3. Select **ICILS (Using Student Weights)** as **the Analysis Type**.
4. Select **Percentages and Means** as the **Statistic Type**.
5. Select **Use PVs** as the **Plausible Value Option**.
6. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
7. The default value selected in the **Show Graphs** menu is **Yes**. For this analysis, selecting **Yes** will produce three graphs in the output file: a line graph of the average achievement for each gender by country, a clustered bar graph of average achievement for each gender by country, and a stacked bar graph of average percent of students for each gender by country. R also produces graphs separately for each country.
8. Specify the variable SGENDER as a second grouping variable by first clicking the **Grouping Variables** field to activate it. Then, select SGENDER from the list of variables in the left panel, and move it to the **Grouping Variables** field by clicking the **right arrow**(▶) button. The IEA IDB Analyzer automatically checks the **Exclude Missing From Analysis**, which excludes cases with missing values on the grouping variables from the analysis. This box should be checked for this analysis.
9. The **Separate Tables** by field should be empty for this analysis. This field is used to separately analyze several grouping variables or several continuous dependent (not achievement) variables. See the Help manual for more information.

10. Specify the achievement scores to be used for the analysis by first clicking the **Plausible Values** field to activate it. Then, select PVCIL01–05 from the list of available variables in the left panel, and move it to the right **Plausible Values** field by clicking the **right arrow**(▶) button.

11. The **Weight Variable** is selected automatically by the software; TOTWGTS is selected by default because this example analysis uses student context data.

12. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define/Modify** button in the **Output Files** field. The IEA IDB Analyzer also will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the analysis. In Figure 4.7, the syntax file CIL_byGender.R and the output files with the same name will be created and stored in the `C:\ICILS2023\Analysis` folder.

13. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the**Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

The IDB Analyzer produces and saves the results output in three file formats within the folder specified in step 12—an HTML output file (or output in SPSS/SAS), R data file (*.Rdata), and Microsoft Excel Worksheet (*.xlsx). The output files are named using the same name specified for the syntax file in step 12. The HTML reports produced by R are named with the suffix "_PVCIL" indicating the outcome variable. Graphs are included only in the HTML output files. For the Percentages and Means statistic using a second grouping variable (i.e., in addition to IDCNTRY), the IEA IDB Analyzer produces two additional results files in Rdata and xlsx formats. The output file named with the suffix "_sig" reports the significance of the differences between analysis groups—in this case girls and boys—for each country. The output file named with the suffix "_sig2" reports the significance of differences between countries within each of the gender groups.

The results of this example as shown in the R output file are presented in Figure 4.8 with the first 10 ICILS 2023 countries listed. The results are presented in the "Report" section of the R output.

Countries are ordered sequentially according to their numeric ISO code (see Chapter 2). Each country's results are displayed on two lines, one for each value of the grouping variable (SGENDER). The country is identified in the first column (Cntry ID) and the second column (Sex of Students) indicates the category of the grouping variable SGENDER being reported according to the value labels (1: Girl, 2: Boy). The third column reports the number of valid cases (N of Cases), the fourth column reports the sum of weights of the sampled students (Sum of TOTWGTS), indicating the estimated total students in the population represented by the sample, and the fifth column is the standard error of the sum of weights (Sum of TOTWGTS (s.e.)).

The next two columns report the weighted percentage of students in the particular category of the second grouping variable (Percent), which for this analysis is the percent of students in each category of SGENDER within IDCNTRY, and its standard error (Percent (s.e.)). The next two columns report the estimated average for the outcome variable for the group, in this case average CIL scores (PVCIL (Mean)) and its standard error (PVCIL (s.e.)). The subsequent column reports the 95 percent confidence intervals around the mean. The standard deviation of the achievement scores (Std.Dev.) and its standard error (Std.Dev. (s.e.)) are reported in the next two columns. The last two columns report the percentage of cases with missing data (Percent Missing) and the number of jackknife zones used for computing standard errors (Number of Variance Strata), respectively.

Figure 4.8: Output for example student-level analysis with CIL achievement scores by gender

Report

Analysis for PVCIL by IDCNTRY SGENDER

Cntry ID	Gender	N of Cases	Sum of TOTWGTS	Sum of TOTWGTS (s.e.)	Percent	Percent (s.e.)	PVCIL (Mean)	PVCIL (s.e.)	Confidence Interval (95)	Std.Dev.	Std.Dev. (s.e.)	Percent Missing	Number of Variance Strata
Azerbaijan, Republic of	Female	1742	72449	2692.14	47.22	0.89	329.32	5.39	319 - 340	98.43	3.56	0.00	75
Azerbaijan, Republic of	Male	1892	80994	3461.01	52.78	0.89	309.11	5.65	298 - 320	101.06	3.56	0.00	75
Austria	Female	1753	37844	1233.79	50.75	1.39	512.94	2.83	507 - 518	73.72	2.18	0.00	75
Austria	Male	1614	36726	1382.85	49.25	1.39	497.61	3.17	491 - 504	77.68	2.41	0.00	75
Bosnia and Herzegovina	Female	911	8465	320.40	47.80	1.28	447.07	4.59	438 - 456	100.35	2.87	0.00	57
Bosnia and Herzegovina	Male	966	9243	279.53	52.20	1.28	434.07	4.83	425 - 444	107.64	3.71	0.00	57
Chile	Female	1596	124749	5239.68	48.99	1.74	433.68	4.65	425 - 443	97.82	2.46	0.00	65
Chile	Male	1608	129918	5400.74	51.01	1.74	425.65	4.55	417 - 435	96.37	2.13	0.00	65
Chinese Taipei	Female	2355	86259	1845.76	46.45	0.75	531.30	2.86	526 - 537	80.75	2.05	0.00	75
Chinese Taipei	Male	2757	99445	1624.48	53.55	0.75	501.36	3.79	494 - 509	89.09	2.31	0.00	75
Croatia	Female	1408	18543	710.79	49.13	0.77	505.28	4.56	496 - 514	92.28	3.36	0.00	74
Croatia	Male	1502	19198	691.34	50.87	0.77	468.72	4.68	460 - 478	102.35	2.52	0.00	74
Cyprus	Female	1621	4874	79.75	50.94	0.73	473.33	2.94	468 - 479	93.62	2.03	0.00	75
Cyprus	Male	1561	4694	91.05	49.06	0.73	447.02	3.73	440 - 454	106.76	2.52	0.00	75
Czech Republic	Female	4034	56065	1325.01	49.07	0.74	527.05	2.43	522 - 532	68.08	1.99	0.00	75
Czech Republic	Male	4135	58192	1250.83	50.93	0.74	523.79	2.11	520 - 528	68.96	1.60	0.00	75
Denmark	Female	1449	29214	823.95	48.72	0.97	530.82	2.61	526 - 536	69.88	1.93	0.00	71
Denmark	Male	1529	30748	1008.60	51.28	0.97	507.96	3.57	501 - 515	77.43	2.85	0.00	71
Finland	Female	2128	29452	799.18	50.60	1.01	518.69	3.52	512 - 526	79.47	2.04	0.00	75
Finland	Male	2121	28755	782.30	49.40	1.01	494.40	4.46	486 - 503	89.40	2.76	0.00	75

The results for Azerbaijan are interpreted here as an example. From the two lines of results for Azerbaijan in Figure 4.8, the population estimates show somewhat more boys than girls: 47.22 percent of students were girls (standard error of 0.89) and 52.78 percent were boys (standard error of 0.89). The average CIL score of girls was 329.32 (standard error of 5.39) and it was 309.11 for boys (standard error of 5.65).

While the 95 percent confidence intervals for boys and girls overlap in Azerbaijan the upper boundaries of the confidence interval for girls are 20 points above those for boys. The lower boundaries for the confidence interval associated with girls are 21 points above the lower confidence bound for boys in Azerbaijan. When confidence intervals do not overlap, this can be taken as an indication that a significance test of the mean difference with alpha error 100-95%=5% would reject the null hypothesis. However, somewhat overlapping confidence intervals do not necessarily indicate a non-significant result at the same alpha level.

The statistical significance of the gender differences can be determined by examining the output file named with the suffix "_sig" (CIL_byGender_PVCIL_by_SGENDER_sig in this example) provided in R data (*.Rdata) and Excel (*.xlsx) file formats. This example refers to the xlsx version, which is the same for all software, shown in Figure 4.9.

Figure 4.9: Excel "Sig" Output for analysis of average CIL by gender

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	IDCNTRY	dvar	groupvar	refgroup	compgroup	pct	pct_se	cpct	cpct_se	pctdiff	pctdiff_se	pctdiff_t	mnpv	mnpv_se	cmnpv	cmnpv_se	mnpvdiff	mnpvdiff_se	mnpvdiff_t	mnpvdiff_ci
2	Azerbaijan,	PVCIL	SGENDER	Female	Female	47,22	0,89	47,22	0,89	0,00	0,00	#NUM!	329,32	5,39	329,32	5,39	0,00	0,00	#NUM!	#N/A
3	Azerbaijan,	PVCIL	SGENDER	Female	Male	47,22	0,89	52,78	0,89	5,57	1,77	3,14	329,32	5,39	309,11	5,65	-20,20	4,39	-4,61	-29 to -12
4	Azerbaijan,	PVCIL	SGENDER	Male	Female	52,78	0,89	47,22	0,89	-5,57	1,77	-3,14	309,11	5,65	329,32	5,39	20,20	4,39	4,61	12 to 29
5	Azerbaijan,	PVCIL	SGENDER	Male	Male	52,78	0,89	52,78	0,89	0,00	0,00	#NUM!	309,11	5,65	309,11	5,65	0,00	0,00	#NUM!	#N/A
6	Austria	PVCIL	SGENDER	Female	Female	50,75	1,39	50,75	1,39	0,00	0,00	#NUM!	512,94	2,83	512,94	2,83	0,00	0,00	#NUM!	#N/A
7	Austria	PVCIL	SGENDER	Female	Male	50,75	1,39	49,25	1,39	-1,50	2,78	-0,54	512,94	2,83	497,61	3,17	-15,32	3,28	-4,67	-22 to -9
8	Austria	PVCIL	SGENDER	Male	Female	49,25	1,39	50,75	1,39	1,50	2,78	0,54	497,61	3,17	512,94	2,83	15,32	3,28	4,67	9 to 22
9	Austria	PVCIL	SGENDER	Male	Male	49,25	1,39	49,25	1,39	0,00	0,00	#NUM!	497,61	3,17	497,61	3,17	0,00	0,00	#NUM!	#N/A
10	Bosnia and I	PVCIL	SGENDER	Female	Female	47,80	1,28	47,80	1,28	0,00	0,00	#NUM!	447,07	4,59	447,07	4,59	0,00	0,00	#NUM!	#N/A
11	Bosnia and I	PVCIL	SGENDER	Female	Male	47,80	1,28	52,20	1,28	4,40	2,57	1,71	447,07	4,59	434,07	4,83	-13,00	5,73	-2,27	-24 to -2
12	Bosnia and I	PVCIL	SGENDER	Male	Female	52,20	1,28	47,80	1,28	-4,40	2,57	-1,71	434,07	4,83	447,07	4,59	13,00	5,73	2,27	2 to 24
13	Bosnia and I	PVCIL	SGENDER	Male	Male	52,20	1,28	52,20	1,28	0,00	0,00	#NUM!	434,07	4,83	434,07	4,83	0,00	0,00	#NUM!	#N/A
14	Chile	PVCIL	SGENDER	Female	Female	48,99	1,74	48,99	1,74	0,00	0,00	#NUM!	433,68	4,65	433,68	4,65	0,00	0,00	#NUM!	#N/A
15	Chile	PVCIL	SGENDER	Female	Male	48,99	1,74	51,01	1,74	2,03	3,48	0,58	433,68	4,65	425,65	4,55	-8,03	4,96	-1,62	-18 to 2
16	Chile	PVCIL	SGENDER	Male	Female	51,01	1,74	48,99	1,74	-2,03	3,48	-0,58	425,65	4,55	433,68	4,65	8,03	4,96	1,62	-2 to 18
17	Chile	PVCIL	SGENDER	Male	Male	51,01	1,74	51,01	1,74	0,00	0,00	#NUM!	425,65	4,55	425,65	4,55	0,00	0,00	#NUM!	#N/A
18	Chinese Tai	PVCIL	SGENDER	Female	Female	46,45	0,75	46,45	0,75	0,00	0,00	#NUM!	531,30	2,86	531,30	2,86	0,00	0,00	#NUM!	#N/A
19	Chinese Tai	PVCIL	SGENDER	Female	Male	46,45	0,75	53,55	0,75	7,10	1,51	4,71	531,30	2,86	501,36	3,79	-29,94	3,30	-9,06	-36 to -23
20	Chinese Tai	PVCIL	SGENDER	Male	Female	53,55	0,75	46,45	0,75	-7,10	1,51	-4,71	501,36	3,79	531,30	2,86	29,94	3,30	9,06	23 to 36
21	Chinese Tai	PVCIL	SGENDER	Male	Male	53,55	0,75	53,55	0,75	0,00	0,00	#NUM!	501,36	3,79	501,36	3,79	0,00	0,00	#NUM!	#N/A
22	Croatia	PVCIL	SGENDER	Female	Female	49,13	0,77	49,13	0,77	0,00	0,00	#NUM!	505,28	4,56	505,28	4,56	0,00	0,00	#NUM!	#N/A
23	Croatia	PVCIL	SGENDER	Female	Male	49,13	0,77	50,87	0,77	1,73	1,54	1,13	505,28	4,56	468,72	4,68	-36,55	5,13	-7,13	-47 to -27
24	Croatia	PVCIL	SGENDER	Male	Female	50,87	0,77	49,13	0,77	-1,73	1,54	-1,13	468,72	4,68	505,28	4,56	36,55	5,13	7,13	27 to 47
25	Croatia	PVCIL	SGENDER	Male	Male	50,87	0,77	50,87	0,77	0,00	0,00	#NUM!	468,72	4,68	468,72	4,68	0,00	0,00	#NUM!	#N/A
26	Cyprus	PVCIL	SGENDER	Female	Female	50,94	0,73	50,94	0,73	0,00	0,00	#NUM!	473,33	2,94	473,33	2,94	0,00	0,00	#NUM!	#N/A
27	Cyprus	PVCIL	SGENDER	Female	Male	50,94	0,73	49,06	0,73	-1,88	1,46	-1,28	473,33	2,94	447,02	3,73	-26,31	4,34	-6,06	-35 to -18
28	Cyprus	PVCIL	SGENDER	Male	Female	49,06	0,73	50,94	0,73	1,88	1,46	1,28	447,02	3,73	473,33	2,94	26,31	4,34	6,06	18 to 35
29	Cyprus	PVCIL	SGENDER	Male	Male	49,06	0,73	49,06	0,73	0,00	0,00	#NUM!	447,02	3,73	447,02	3,73	0,00	0,00	#NUM!	#N/A
30	Czech Repu	PVCIL	SGENDER	Female	Female	49,07	0,74	49,07	0,74	0,00	0,00	#NUM!	527,05	2,43	527,05	2,43	0,00	0,00	#NUM!	#N/A
31	Czech Repu	PVCIL	SGENDER	Female	Male	49,07	0,74	50,93	0,74	1,86	1,47	1,26	527,05	2,43	523,79	2,11	-3,26	1,77	-1,84	-7 to 0
32	Czech Repu	PVCIL	SGENDER	Male	Female	50,93	0,74	49,07	0,74	-1,86	1,47	-1,26	523,79	2,11	527,05	2,43	3,26	1,77	1,84	0 to 7
33	Czech Repu	PVCIL	SGENDER	Male	Male	50,93	0,74	50,93	0,74	0,00	0,00	#NUM!	523,79	2,11	523,79	2,11	0,00	0,00	#NUM!	#N/A

For each country, the "sig" output reports the average CIL score difference between the reference group (column D) and the comparison group (column E) in column Q, labeled "mnpvdiff." Dividing this value by its standard error ("mnpvdiff_se" in column R) gives a t-statistic ("mnpvdiff_t" in column S) for evaluating whether the estimated difference is significantly different from zero. For an error level (α) of 5 percent, values greater than +1.96 (the upper critical value) or less than −1.96 (the lower critical value) indicate that the difference between the reference group (girls) average and the comparison group (boys) average is significantly different from zero. Values between −1.96 and +1.96 (the lower and upper critical values for $\alpha = 0.05$) indicate the achievement difference between the two groups is not significantly different from zero.

The t-value for the achievement difference between girls and boys in Azerbaijan is −4.61, which is below the lower critical t-values for an α level of 0.05. The (null) hypothesis was rejected, indicating the CIL score difference is statistically significant.

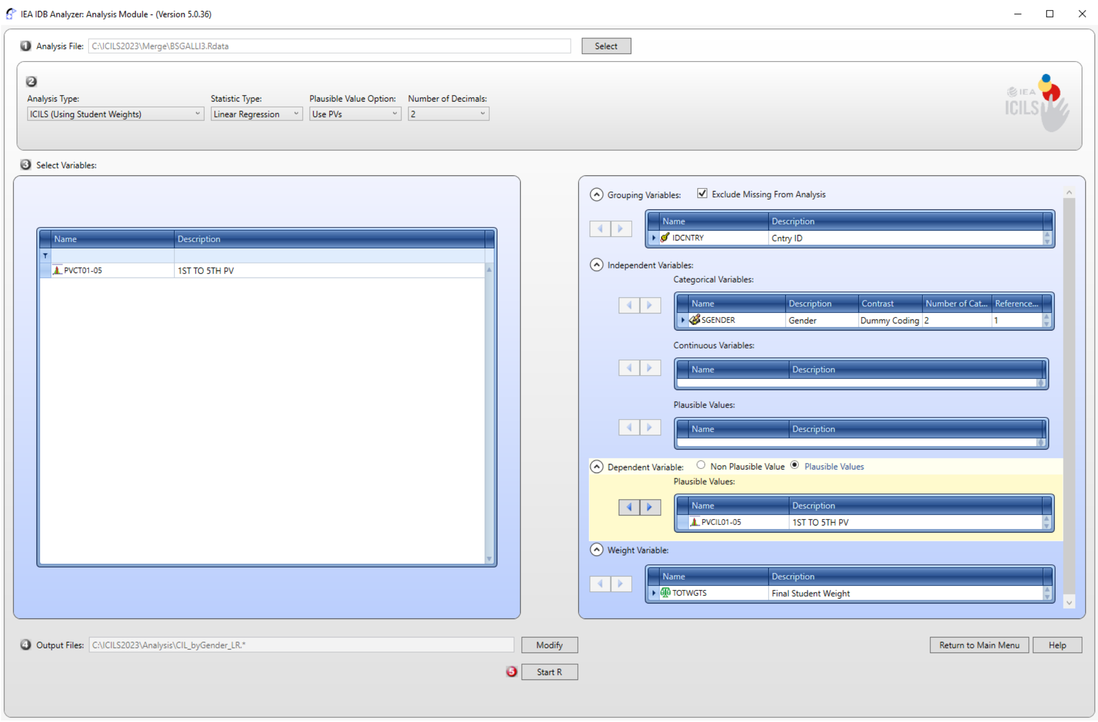
Linear regression analysis with student data

The third example is an extension of the previous analysis and describes an alternative method to examine the difference in CIL scores between girls and boys, as well as determining statistical significance. This example also demonstrates the Dummy Coding feature of the IEA IDB Analyzer. Like the previous example the results of this example are presented in the ICILS 2023 international report (Fraillon, 2024) and are shown above in Table 4.3 in the column labeled "Difference CIL score averages."

The SGENDER variable has a value of one (1) for girls and two (2) for boys. By using SGENDER as a categorical variable in the IEA IDB Analyzer with Dummy Coding and defining category 1 (girls) as the reference category, the regression intercept estimate is the average CIL score of girls, and the regression slope is the estimated change in average CIL score for boys.

The **Analysis Module** of the IEA IDB Analyzer is used to conduct the analysis, with **Linear Regression** defined as the statistic type in the following steps. Figure 4.10 shows the completed Analysis Module for this example.

Figure 4.10: IEA IDB Analyzer setup for example student-level regression analysis with CIL scores



1. Open the **Analysis Module** of the IEA IDB Analyzer.
2. Select the merged data file BSGALLI3 as the **Analysis File** by clicking the **Select** button.
3. Select **ICILS (Using Student Weights)** as the **Analysis Type**.
4. Select **Linear Regression** as the **Statistic Type**.
5. Select **Use PVs** as the **Plausible Value Option**.
6. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
7. The box for **Exclude Missing From Analysis** should be checked for this analysis. This option uses listwise deletion, excluding records with missing values on any of the analysis variables.
8. The IDB Analyzer automatically selects the variable IDCNTRY for the **Grouping Variables**. No additional grouping variables are needed for this analysis.
9. Specify SGENDER as a **Categorical Variable** in the **Independent Variables** section, first by clicking the **Categorical Variables** field to activate it. Then, select SGENDER from the list of available variables in the left panel, and move it to the right **Categorical Variables** field by clicking the **right arrow**(▶) button. Next, click the **Contrast** field of SGENDER, and its drop-down menu will appear. **Dummy Coding** is selected by default, and the IEA IDB Analyzer determines the **Number of Categories** for the variable SGENDER (2). By default, category 1 (girls) will be selected as the **Reference Category**. These settings should not be changed.

10. In the **Dependent Variable** section, click the **Plausible Values** radio button. Specify the achievement scores to be used as the **Dependent Variable** by first clicking the **Plausible Values** field to activate it. Then, select PVCIL01–05 from the list of available variables in the left panel, and move it to the right **Plausible Values** field by clicking the **right arrow**(▶) button.
11. The **Weight Variable** is selected automatically by the software; TOTWGTS is selected by default because this example analysis uses student context data.
12. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define/Modify** button in the **Output Files** field. The IEA IDB Analyzer also will create a syntax file of the same name and in the same folder, with the code necessary to perform the analysis. In Figure 4.10, the syntax file CIL_byGender_LR.R and the output files with the same name will be created and stored in the `C:\ICILS2023\Analysis` folder.
13. Click the **Start R** button to create the R script and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

Conducting a linear regression analysis with the IEA IDB Analyzer produces several results output files. The main results for this example are the regression coefficients, reported in the file named with the suffix "_Coef." Separate output files are also produced with descriptive statistics by country, named with the suffix "_Desc" for the intercept (girls' average achievement) and the regression coefficients (change in achievement from girls to boys), and with estimated R-square values for the regression models, named with the suffix "_Model" (MAT_byGender_LR_Model). All results are included in the HTML output produced by R.

Figure 4.11 displays the main results for this example analysis—the regression coefficients—in the R output file for the countries Azerbaijan, Austria, Bosnia and Herzegovina, Chile, Chinese Taipei, Croatia, Cyprus, the Czech Republic, Denmark, and Finland. Countries are ordered numerically according to their numeric ISO code (see Chapter 2), with their results each displayed on two lines: the first for the intercept (CONSTANT) and the second for the SGENDER coefficient (SGENDER_D2). For all regression analyses, there will be as many lines per country as there are regression coefficients, including the intercept.

Figure 4.11: Output for example student-level linear regression analysis with CIL scores

Regression Coefficients

Cntry ID	Variable	Regression Coefficient	Regression Coefficient (s.e.)	Regression Coefficient (t-value)	Stndrdzd. Coefficient	Stndrdzd. Coefficient (s.e.)	Stndrdzd. Coefficient (t-value)
Azerbaijan, Republic of	(CONSTANT)	329.32	5.39	61.12	NaN	NaN	NaN
Azerbaijan, Republic of	SGENDER_D2	-20.20	4.39	-4.61	-0.10	0.02	-4.76
Austria	(CONSTANT)	512.94	2.83	181.14	NaN	NaN	NaN
Austria	SGENDER_D2	-15.32	3.28	-4.67	-0.10	0.02	-4.73
Bosnia and Herzegovina	(CONSTANT)	447.07	4.59	97.33	NaN	NaN	NaN
Bosnia and Herzegovina	SGENDER_D2	-13.00	5.73	-2.27	-0.06	0.03	-2.31
Chile	(CONSTANT)	433.68	4.65	93.29	NaN	NaN	NaN
Chile	SGENDER_D2	-8.03	4.96	-1.62	-0.04	0.03	-1.62
Chinese Taipei	(CONSTANT)	531.30	2.86	185.94	NaN	NaN	NaN
Chinese Taipei	SGENDER_D2	-29.94	3.30	-9.06	-0.17	0.02	-9.33
Croatia	(CONSTANT)	505.28	4.56	110.88	NaN	NaN	NaN
Croatia	SGENDER_D2	-36.55	5.13	-7.13	-0.18	0.03	-7.07
Cyprus	(CONSTANT)	473.33	2.94	160.99	NaN	NaN	NaN
Cyprus	SGENDER_D2	-26.31	4.34	-6.06	-0.13	0.02	-6.29
Czech Republic	(CONSTANT)	527.05	2.43	216.94	NaN	NaN	NaN
Czech Republic	SGENDER_D2	-3.26	1.77	-1.84	-0.02	0.01	-1.83
Denmark	(CONSTANT)	530.82	2.61	203.67	NaN	NaN	NaN
Denmark	SGENDER_D2	-22.86	3.62	-6.31	-0.15	0.02	-6.56
Finland	(CONSTANT)	518.69	3.52	147.50	NaN	NaN	NaN
Finland	SGENDER_D2	-24.29	3.80	-6.39	-0.14	0.02	-6.79

The countries are identified in the first column (Cntry ID) and the second column (Variable) indicates the intercept (CONSTANT) or the regression coefficient being reported. The third column reports the "Regression Coefficient" ("b" in Excel), indicating, for the intercept, the average value of the dependent variable for the reference group (girls in this case), and for the regression coefficients, the average difference in the dependent variable from the intercept. The fourth column is the standard error of the regression coefficient (Regression Coefficient (s.e.)). The fifth column reports the value of the t-statistic for the regression coefficient (Regression Coefficient (t-value)). The IEA IDB Analyzer also computes standardized regression coefficients in the last three columns, corresponding to the third, fourth, and fifth columns, whereby the dependent and independent variables are standardized to have a mean of zero (0) and standard deviation of one (1).

In Figure 4.11, the first line of results for Azerbaijan, labeled "(CONSTANT)" ("Intercept" in SAS), indicates the estimated average CIL score of girls in Azerbaijan: 329.32 with a standard error of 5.39. This estimate concurs with the results obtained in the previous example (Figure 4.8). From the second line of results labeled "SGENDER_D2," the boys in Azerbaijan had a negative average CIL score difference from girls of –20.20 with an estimated standard error of 4.39. The t-value for the coefficient is –4.61, which is lower than –1.96 (the lower critical value for $\alpha = 0.05$), indicating this achievement difference is statistically significant. Counting the two regression coefficients together (329.3 – 20.2) yields the estimated average CIL score of boys in Azerbaijan, which was 309.1 in Figure 4.8.

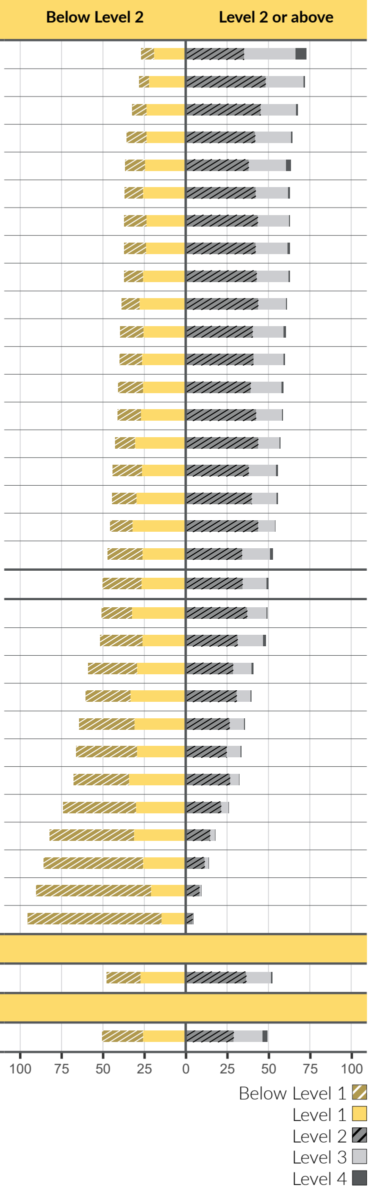
Calculating percentages of students reaching proficiency levels

This section describes how the IEA IDB Analyzer can be used to perform benchmark analyses, which compute the percentages of students reaching specified proficiency levels on the CIL achievement scale and within specified subgroups, along with appropriate standard errors.

As an example, we now describe how the IDB Analyzer can be used to compute the percentages of students (not) reaching the four ICILS 2023 international proficiency levels of CIL achievement (level 1 = 407 to 491 scale points; level 2 = 492 to 576 score points; level 3 = 577 to 661 score points; and level 4 = above 661 scale points) using the merged BSGALLI3 data file. This analysis replicates results from the ICILS 2023 international report (Fraillon, 2024) shown in Table 4.4.

Table 4.4: Percentage of students at each CIL proficiency level across countries

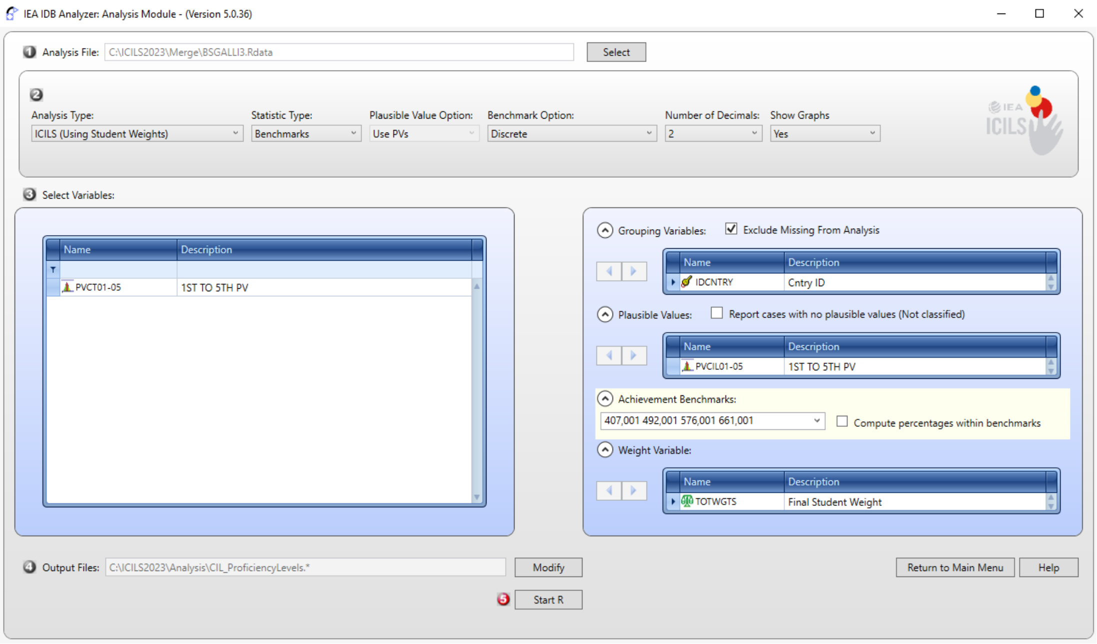
Country	Percentage of students achieving at each CIL level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
† Korea, Republic of	8 (0.6)	19 (0.9)	35 (1.2)	31 (1.1)	6 (0.6)
1 Czech Republic	6 (0.7)	22 (0.9)	48 (1.0)	23 (0.8)	1 (0.2)
†1 Denmark	8 (0.9)	24 (1.0)	45 (1.2)	22 (1.1)	1 (0.3)
† Belgium (Flemish)	12 (1.6)	24 (1.4)	42 (1.7)	22 (1.5)	1 (0.3)
Chinese Taipei	12 (1.0)	25 (1.0)	38 (1.2)	23 (1.3)	3 (0.4)
1 Portugal	11 (1.0)	26 (1.1)	42 (1.3)	20 (1.1)	1 (0.2)
Hungary	13 (1.6)	24 (1.3)	44 (1.3)	19 (1.1)	1 (0.2)
Finland	13 (1.2)	24 (1.0)	42 (1.2)	19 (1.1)	1 (0.3)
1 Latvia	11 (1.2)	26 (1.3)	43 (1.5)	19 (1.3)	1 (0.2)
1 Austria	11 (0.9)	28 (1.2)	44 (1.2)	17 (0.8)	1 (0.2)
1 Sweden	14 (1.1)	25 (1.3)	41 (1.3)	19 (1.4)	1 (0.2)
1 Norway (Grade 9)	14 (1.0)	26 (1.0)	41 (1.0)	18 (1.0)	1 (0.2)
Germany	15 (1.4)	26 (1.2)	39 (1.4)	19 (1.2)	1 (0.3)
Slovak Republic	14 (1.0)	27 (1.2)	43 (1.2)	16 (1.1)	1 (0.2)
France	12 (1.3)	30 (1.3)	44 (1.5)	13 (0.8)	0 (0.1)
Luxembourg	18 (0.8)	26 (0.8)	38 (0.9)	17 (0.9)	1 (0.2)
1 Spain	15 (0.8)	30 (0.8)	40 (0.8)	15 (0.7)	1 (0.2)
Italy	14 (1.2)	32 (1.1)	44 (1.5)	10 (0.8)	0 (0.1)
1 Croatia	21 (1.7)	26 (1.2)	34 (1.6)	17 (1.2)	2 (0.3)
ICILS 2023 average	24 (0.2)	27 (0.2)	34 (0.2)	14 (0.2)	1 (0.0)
1 Slovenia	18 (1.0)	32 (1.0)	37 (1.2)	12 (0.7)	0 (0.2)
Malta	25 (1.0)	26 (0.9)	31 (1.1)	15 (1.1)	2 (0.2)
Cyprus	30 (1.2)	29 (1.4)	29 (1.2)	11 (0.8)	1 (0.3)
Greece	27 (1.5)	33 (1.1)	31 (1.2)	8 (0.9)	0 (0.1)
† Uruguay	33 (1.6)	31 (1.1)	27 (1.4)	9 (0.8)	0 (0.2)
3 Bosnia and Herzegovina	37 (1.6)	29 (1.3)	25 (1.4)	9 (0.9)	1 (0.2)
1 Serbia	33 (1.7)	34 (1.2)	27 (1.4)	5 (0.5)	0 (0.1)
†12 Romania	44 (2.3)	30 (1.4)	21 (1.5)	4 (0.5)	0 (0.1)
1 Kazakhstan	51 (1.6)	31 (1.4)	15 (1.0)	3 (0.5)	0 (0.0)
Oman	60 (1.2)	26 (0.8)	11 (0.7)	2 (0.3)	0 (0.1)
1 Kosovo	70 (1.7)	21 (1.3)	8 (0.8)	1 (0.3)	0 (0.1)
Azerbaijan	81 (1.7)	15 (1.2)	4 (0.6)	0 (0.2)	0 (0.0)
Benchmarking participant					
1 North Rhine-W. (Germany)	20 (1.6)	27 (1.1)	37 (1.3)	15 (1.3)	1 (0.2)
Countries not meeting sample participation requirements					
‡ United States	25 (2.2)	26 (1.4)	29 (1.8)	18 (2.0)	3 (0.6)



Notes: Standard error appear in parentheses (). Because of rounding some results may appear inconsistent. ICILS 2023 average is based on all non-benchmarking participants that met sampling participation requirements except Romania. Countries are ranked in descending order of the percentage of students reaching Level 2 or above.
† Met guidelines for sampling participation rates only after replacement schools were included.
‡ Does not meet guideline for sampling participation rate, but achieved at least 50% overall sampling participation rate.
1 National defined population covers 90% to 95% of the national target population. See Appendix A for further information.
2 Country surveyed target grade in the first half of the school year.
3 National defined population covers 61% of the national target population.

This example is conducted in the Analysis Module of the IEA IDB Analyzer with the following steps. The completed Analysis Module is shown in Figure 4.12

Figure 4.12: IEA IDB Analyzer setup for example proficiency level analysis with CIL scores



1. Open the **Analysis Module** of the IEA IDB Analyzer.
2. Specify the data file BSGALLLI3 as the **Analysis File** by clicking the **Select** button.
3. Select **ICILS (Using Student Weights)** as the **Analysis Type**.
4. Select **Benchmarks** as the **Statistic Type**.
5. Select the **Discrete** option under the **Benchmark Option** drop-down menu to get discrete percentages of students reaching the ICILS 2023 proficiency levels.
6. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
7. The variable IDCNTRY is selected automatically for **Grouping Variables**. No additional grouping variables are needed for this analysis.
8. Specify the achievement scores to be used for the analysis by first clicking the **Plausible Values** field to activate it. Then, select PVCIL01–05 from the list of available variables in the left panel, and move it to the right Plausible Values field by clicking the **right arrow**(▶) button.
9. In the **Achievement Benchmarks** field, specify the average achievement score for each of the LaNA International Benchmarks in ascending order – 407, 492, 576, and 661 (level 1, level 2, level 3, and level 4, respectively).
10. The **Weight Variable** is selected automatically by the software; TOTWGTS is selected by default because this example analysis uses student data.
11. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define/Modify** button in the **Output Files** field. The IEA IDB Analyzer will create a syntax file with the code necessary to perform the analysis. In Figure 4.12, the syntax file CIL_ProficiencyLevels.R and the output files with the same name will be created and stored in the folder `C:\ICILS2023\Analysis`.
12. Click the **Start R** button to create the R script and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R

script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

The IEA IDB Analyzer produces and saves the results output in three file formats within the folder specified in step 11—an HTML output file (or output in SPSS/SAS), R data file (*.Rdata), and Microsoft Excel Worksheet (*.xlsx). Graphs are included only in the HTML (or SPSS/SAS) output files. Figure 4.13 presents the results of this example as shown in the R output, under the "Report" section. Results are shown for the first two countries: Azerbaijan and Austria.

Countries are ordered according to their numeric ISO code (see Chapter 2), and each country's results are displayed on five lines, one for each ICILS 2023 proficiency level while the first line indicates the percentage of students below level 1. The countries are identified in the first column (Cntry ID) and the second column (cutvar) indicates the proficiency level being reported (this is labeled "Performance Group" in SPSS). The third column reports the number of valid cases (N of Cases), the fourth column reports the sum of weights of the sampled students (Sum of TOTWGTS) corresponding to the number of students in the population represented by the sample, and the fifth column is the standard error of the sum of weights (Sum of TOTWGTS (s.e.)). The last two columns report the discrete percentage of students reaching each proficiency level (Percent) and its standard error (Percent (s.e.)).

Figure 4.13: Output for example proficiency level analysis CIL scores

Report

Percentage by Performance Group of PVCIL

Cntry ID	cutvar	N of Cases	Sum of TOTWGTS	Sum of TOTWGTS (s.e.)	Percent	Percent (s.e.)
Azerbaijan, Republic of	1. Below 407.001	2857	123816	5546.33	80.69	1.65
Azerbaijan, Republic of	2. From 407.001 to Below 492.001	585	22479	1856.02	14.65	1.21
Azerbaijan, Republic of	3. From 492.001 to Below 576.001	171	6382	997.64	4.16	0.65
Azerbaijan, Republic of	4. From 576.001 to Below 661.001	20	749	296.45	0.49	0.19
Azerbaijan, Republic of	5. At or Above 661.001	0	17	37.91	0.01	0.02
Austria	1. Below 407.001	328	8273	683.26	10.86	0.91
Austria	2. From 407.001 to Below 492.001	851	21242	1013.97	27.87	1.17
Austria	3. From 492.001 to Below 576.001	1547	33412	1250.88	43.84	1.24
Austria	4. From 576.001 to Below 661.001	693	12841	680.90	16.85	0.83
Austria	5. At or Above 661.001	29	441	125.08	0.58	0.16

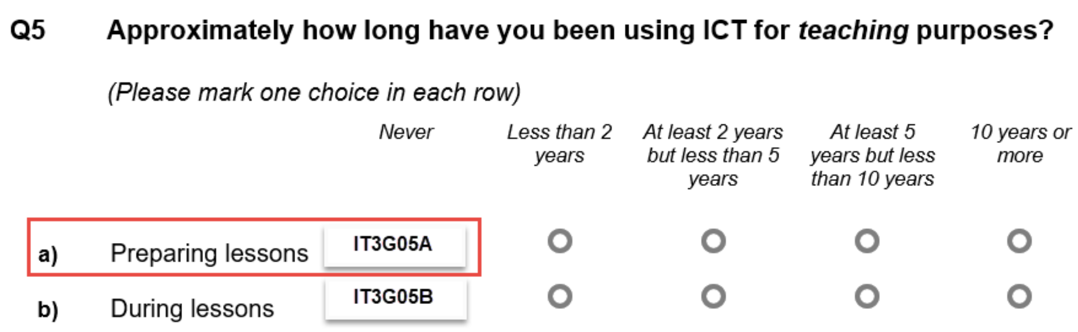
As shown in the five lines of results for Austria, an estimated percentage of 10.86 percent of the students in Austria performed below CIL proficiency level 1 of 407 scale score points, with a standard error of 0.91; an estimated percentage of 27.87 percent of students reached level 1 but are below level 2, with a standard error of 1.17; an estimated percentage of 43.84 percent of students reached level 2 but are below level 3, with a standard error of 1.24; an estimated percentage of 16.85 percent of students reached level 3 but are below level 4, with a standard error of 0.83 and an estimated percentage of 0.58 percent of students reached level 4, with a standard error of 0.16.

4.6 Performing analyses with teacher-level data

As already noted, student and teacher data cannot be merged and analyzed together due to the sampling design of ICILS 2023. The following teacher analysis example calculates the percentage of teachers using ICT for at least 5 years or more for preparing lessons. The analysis can, of course, be conducted only at the level of teachers.

As in previous examples, the first step is to identify the variables relevant to the analysis within the appropriate files. Supplement 1 provides the international versions of the questionnaires, including variable names, thereby linking the questions administered to ICILS 2023 respondents with the corresponding variables in the data files. Upon reviewing the teacher questionnaire, it becomes evident that Question 5A (variable IT3G05A) contains the data needed for this analysis. Figure 4.14 depicts question 5A of the teacher questionnaire.

Figure 4.14: Question 5 of the international version of the ICILS 2023 teacher questionnaire



Q5 Approximately how long have you been using ICT for *teaching* purposes?

(Please mark one choice in each row)

		Never	Less than 2 years	At least 2 years but less than 5 years	At least 5 years but less than 10 years	10 years or more
a)	Preparing lessons	IT3G05A	○	○	○	○
b)	During lessons	IT3G05B	○	○	○	○

Furthermore, it is considered good practice to review the documentation for any specific national adaptations made to the questions of interest (see Supplement 2 of this user guide).

The variable of interest, IT3G05A, includes 5 categories: (1) Never; (2) Less than 2 years; (3) At least 2 years but less than 5 years; (4) At least 5 years but less than 10 years; (5) 10 years or more. Since these categories are more detailed than necessary for this example, they will be simplified into two broader categories: "less than 5 years" and "5 years or more." The R code below demonstrates how to load the merged teacher data file, BTGALLI3.Rdata, into RStudio and recode the five original categories of IT3G05A into a new variable, IT3G05Acol (short for "collapsed"). In addition to performing the recoding, the code ensures proper labeling of the new variable and its values.

```
#1 Install and load haven if not already installed
if (!requireNamespace("haven", quietly = TRUE)) install.packages("haven")
library(haven)

#2 Load merged teacher file
load("C:/ICILS2023/Merge/BTGALLI3.Rdata")

#3 Dichotomize 5A
BTGALLI3[BTGALLI3$IT3G05A %in% c(1,2,3) , "IT3G05Acol"] <- 0
```

```
BTGALLI3[BTGALLI3$IT3G05A %in% c(4,5) , "IT3G05Acol"] <- 1

#4 Setting missing
attributes(BTGALLI3$IT3G05Acol)$na_values <- c(8,9)

#5 Setting value labels
BTGALLI3$IT3G05Acol <- labelled(BTGALLI3$IT3G05Acol, c("Less than 5 years" = 0,
"5 years or more" = 1))

#6 Setting variable labels
attributes(BTGALLI3$IT3G05Acol)$label <- "Dichotomized/Your Use of ICT/Preparing
lessons"

#7 Save the updated object back to the same file
save(BTGALLI3, file = "C:/ICILS2023/Merge/BTGALLI3.Rdata")
```

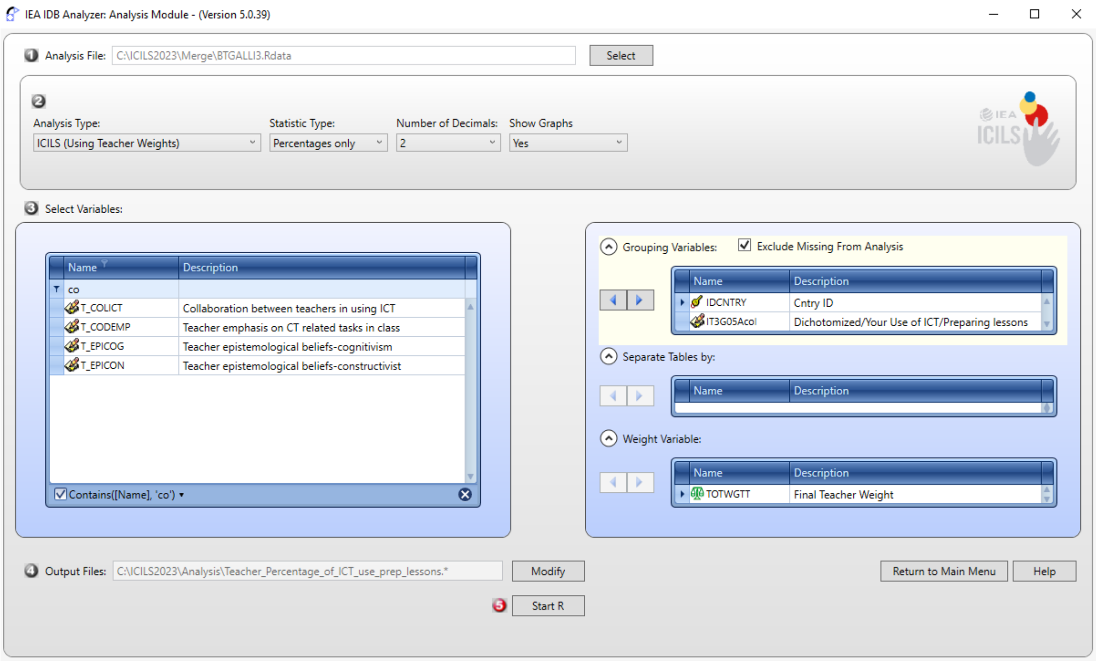
The prerequisites for using this code include having a teacher data file in *.Rdata format. Additionally, you will need to adapt the file locations specified in steps 2 and 7 to suit your system.

It's important to note the command in step 4, which converts the values 8 and 9 to NA. This step is necessary because all ICILS 2023 R data have been derived from corresponding SPSS data files. While R only recognizes a single native missing value (NA), SPSS allows for multiple missing value codes. Upon inspecting the "Missing Scheme Detailed: SPSS" column in the Excel codebook for IT3G05A, we can see that the values 8 and 9 are defined as missing in SPSS. Therefore, to ensure accurate analysis in R, these values must also be excluded when calculating statistics, which is why they are set to NA in step 4. Note that this step is not necessary for any variable part of the IDB, as this information is already included in its metadata.

Once this operation is complete, the next step is to reload the file into the IEA IDB Analyzer. The file is now ready for analysis, and the software will recognize the newly created variable. The IDB Analyzer's analysis module automatically selects the country variable (IDCNTRY) and the variables containing the sampling information, which are used to compute the error estimates.

The analysis module of the IEA IDB Analyzer is then used to perform the example teacher-level analysis as follows. Figure 4.15 shows how the analysis module should appear once the correct settings are entered.

Figure 4.15: IEA IDB Analyzer setup for example teacher level analysis



1. Open the **Analysis Module** of the IEA IDB Analyzer.
2. Select the merged data file BTGALLLI3 as the **Analysis File** by clicking the **Select** button.
3. Select **ICILS (Using Teacher Weights)** as **the Analysis Type**.
4. Select **Percentages only** as the **Statistic Type**.
5. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
6. The default value selected in the **Show Graphs** menu is **Yes**. For this analysis, selecting **Yes** will produce two types of graphs in the output file: a line graph depicting the percentages of the categories of the variable added to the grouping variables per country and a corresponding single bar chart per country. If more than one variable have been added to the grouping variables percentages for each combination will be depicted.
7. Specify the previously created variable IT3G05Acol as a second grouping variable by first clicking the **Grouping Variables** field to activate it. Then, select IT3G05Acol from the list of variables in the left panel, and move it to the **Grouping Variables** field by clicking the **right arrow**(▶) button. The IEA IDB Analyzer automatically checks the **Exclude Missing From Analysis**, which excludes cases with missing values on the grouping variables from the analysis. This box should be checked for this analysis.
8. The **Separate Tables** by field should be empty for this analysis. This field is used to separately analyze several grouping variables or several continuous dependent (not achievement) variables. See the Help manual for more information.
9. The **Weight Variable** is selected automatically by the software; TOTWGTT is selected by default because this example analysis uses teacher context data.
10. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define/Modify** button in the **Output Files** field. The IEA IDB Analyzer also will create an R script (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the

same folder, with the code necessary to perform the analysis. In Figure 4.15, the syntax file Teacher_Percentage_of_ICT_use_prep_lessons.R and the output files with the same name will be created and stored in the `C:\ICILS2023\Analysis` folder.

11. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

The results as shown in the R output file are presented in Figure 4.16. The results are presented in the same manner as in other examples, with countries identified in the first column and the second column describing the categories of IT3G05Acol.

Figure 4.16: Output for example teacher-level analysis

Report

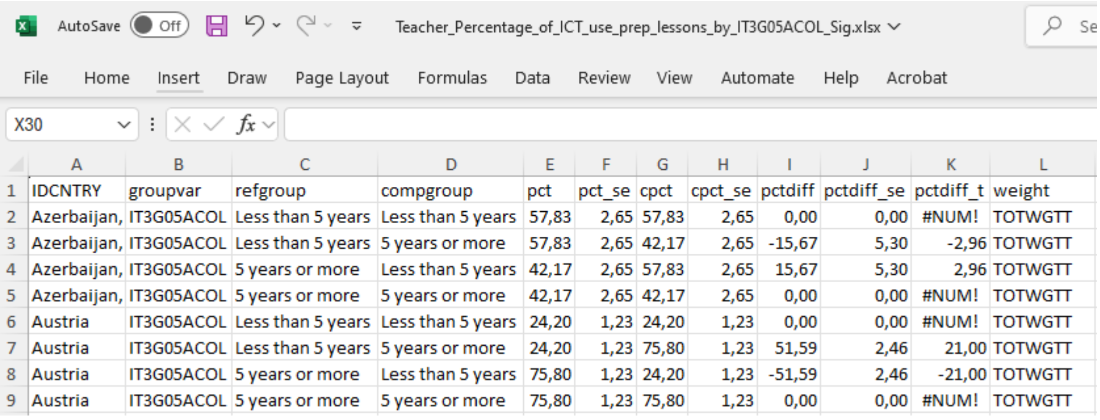
Percentages by IDCNTRY IT3G05ACOL

Cntry ID	Dichotomized/Your Use of ICT/Preparing lessons	N of Cases	Sum of TOTWGTT	Sum of TOTWGTT (s.e.)	Percent	Percent (s.e.)	Number of Variance Strata
Azerbaijan, Republic of	Less than 5 years	1139	20295	1128.71	57.83	2.65	74
Azerbaijan, Republic of	5 years or more	792	14797	1015.70	42.17	2.65	74
Austria	Less than 5 years	379	6839	405.01	24.20	1.23	66
Austria	5 years or more	1241	21416	668.29	75.80	1.23	68

The results for Azerbaijan are interpreted here as an example. From the two lines of results for Austria in Figure 4.16, 47.8 percent of the teachers teaching grade 8 reported that they use ICT for at least 5 years or more for preparing lessons (standard error of 2.6).

The statistical significance of the percentage differences can be determined by examining the output file named with the suffix "_sig" (Teacher_Percentage_of_ICT_use_prep_lessons_by_IT3G05ACOL_Sig in this example) provided in R data (*.Rdata) and Excel (*.xlsx) file formats. This example refers to the xlsx version, which is the same for all software, shown in Figure 4.17.

Figure 4.17: Excel "Sig" Output for analysis of teacher percentages



	A	B	C	D	E	F	G	H	I	J	K	L
1	IDCNTRY	groupvar	refgroup	compgroup	pct	pct_se	cpct	cpct_se	pctdiff	pctdiff_se	pctdiff_t	weight
2	Azerbaijan,	IT3G05ACOL	Less than 5 years	Less than 5 years	57,83	2,65	57,83	2,65	0,00	0,00	#NUM!	TOTWGTT
3	Azerbaijan,	IT3G05ACOL	Less than 5 years	5 years or more	57,83	2,65	42,17	2,65	-15,67	5,30	-2,96	TOTWGTT
4	Azerbaijan,	IT3G05ACOL	5 years or more	Less than 5 years	42,17	2,65	57,83	2,65	15,67	5,30	2,96	TOTWGTT
5	Azerbaijan,	IT3G05ACOL	5 years or more	5 years or more	42,17	2,65	42,17	2,65	0,00	0,00	#NUM!	TOTWGTT
6	Austria	IT3G05ACOL	Less than 5 years	Less than 5 years	24,20	1,23	24,20	1,23	0,00	0,00	#NUM!	TOTWGTT
7	Austria	IT3G05ACOL	Less than 5 years	5 years or more	24,20	1,23	75,80	1,23	51,59	2,46	21,00	TOTWGTT
8	Austria	IT3G05ACOL	5 years or more	Less than 5 years	75,80	1,23	24,20	1,23	-51,59	2,46	-21,00	TOTWGTT
9	Austria	IT3G05ACOL	5 years or more	5 years or more	75,80	1,23	75,80	1,23	0,00	0,00	#NUM!	TOTWGTT

For each country, the "sig" output reports the average percentage difference between the reference group (column C) and the comparison group (column D) in column I, labeled "pctdiff." Dividing this value by its standard error ("pctdiff_se" in column J) gives a t-statistic ("pctdiff_t" in column K) for evaluating whether the estimated difference is significantly different from zero. For an error level (α) of 5 percent, values greater than +1.96 (the upper critical value) or less than −1.96 (the lower critical value) indicate that the difference between the reference group ("less than 5 years") percentage and the comparison group ("5 years or more") percentage is significantly different from zero. Values between −1.96 and +1.96 (the lower and upper critical values for $\alpha = 0.05$) indicate the percentage difference between the two groups is not significantly different from zero.

The t-value for the percentage difference between two regarded groups of teachers in Austria is 21, which is above the upper critical t-values for an α level of 0.05. The (null) hypothesis was rejected, indicating the percentage difference is statistically significant.

4.7 Performing analyses with student-level data augmented with school-level data

When analyzing merged school-level data, the focus is on making statements about the number or percentages of students attending schools with specific characteristics, rather than the number or percentages of schools themselves. In this example, the "Percentages and Means" statistic type is used in combination with the "Use PVs" option to estimate the percentages of students and their average CIL scores, categorized by the school type (public or private) as reported by school principals.

Before conducting analyses using school-level variables, users should consult the codebook for the data file to identify the relevant variables associated with school type and understand the coding scheme. Supplement 1 provides all questionnaires administered in ICILS 2023 along with the corresponding variable names under which the data are saved.

The codebook for the school data file indicates that the principal questionnaire variable IP3G06A captures information about school type. Figure 4.18 illustrates the corresponding Question 6A from the principal questionnaire, including its two response options.

Figure 4.18: Question 6A of the international version of the ICILS 2023 principal questionnaire

Q6A Is your school a public or a private school?

(Please mark one choice only)

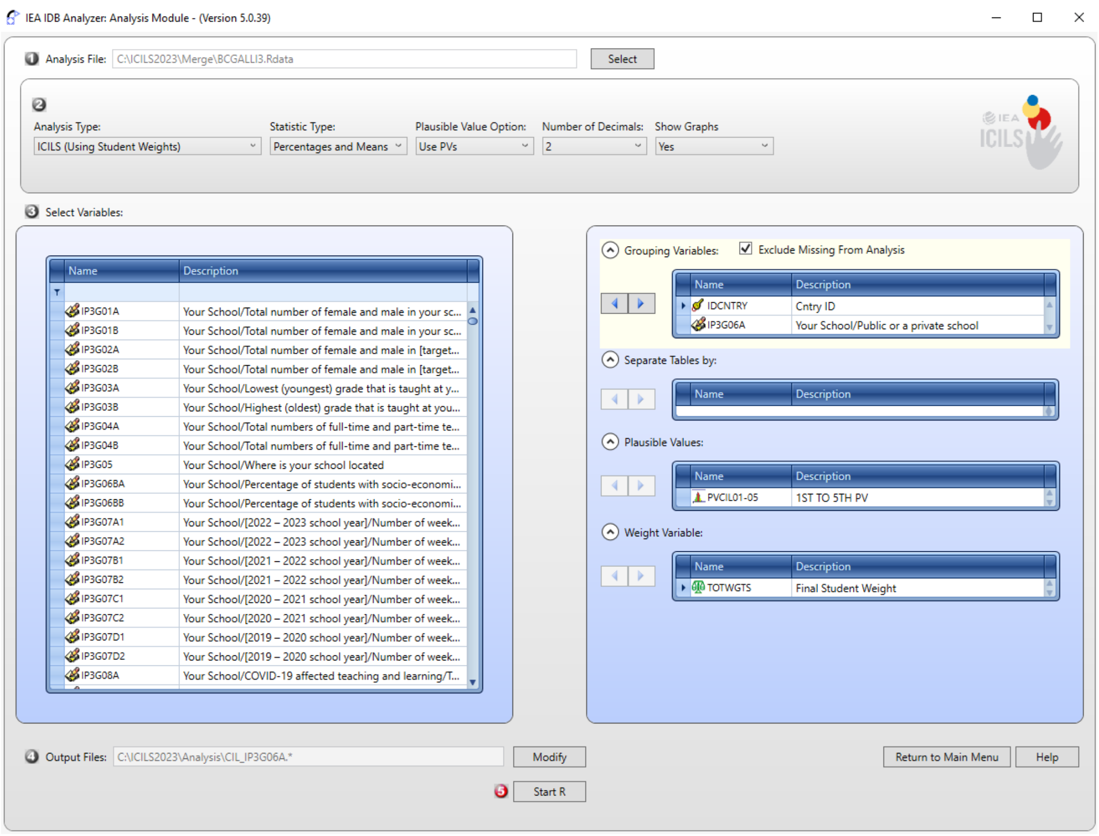
IP3G06A

A public school
(This is a school managed directly or indirectly by a public education authority, government agency, or governing board, appointed by the government or elected by a public franchise.) ○

A private school
(This is a school managed directly or indirectly by a non-government organization; for example, a church, trade union, business, or other private institution.) ○

This example uses the merged data file BCGALLLI3 described earlier in this chapter under Merging Data Files with the IEA IDB Analyzer. This example analysis is conducted in the Analysis Module of the IEA IDB Analyzer using the following steps. The completed Analysis Module is shown in Figure 4.19.

Figure 4.19: IEA IDB Analyzer setup for example student level analysis augmented by school data



1. Open the **Analysis Module** of the IEA IDB Analyzer.
2. Select the merged data file BCGALLI3 as the **Analysis File** by clicking the **Select** button.
3. Select I**CILS (Using Student Weights)** as the **Analysis Type**, because the school context data is analyzed as student attributes.
4. Select **Percentages and Means** as the **Statistic Type**.
5. Select **Use PVs** as the **Plausible Value Option**, because average achievement will be computed by the grouping variable IP3G06A.
6. The default value in the **Number of Decimals** drop-down menu is **2**. Changing this value affects only the number of visible decimal places in the output files.
7. The default value selected in the **Show Graphs** menu is **Yes**. For this analysis, selecting **Yes** will produce three graphs in the output file: a line graph of average achievement for each category of the immediate area of the school location by country, a clustered bar graph of average achievement for each category of school location by country, and a stacked bar graph of average percent of students for each category of school location by country. R also provides separate graphs for each country.
8. Specify the variable IP3G06A as a second grouping variable by first clicking the **Grouping Variables** field to activate it. Then, select IP3G06A from the list of variables in the left panel, and move it to the **Grouping Variables** field by clicking the **right arrow**(▶) button. The IEA IDB Analyzer automatically checks the Exclude Missing From Analysis, which excludes cases with missing values on the grouping variables from the analysis. This box should be checked for this analysis.
9. The Separate Tables by field should be empty for this analysis. This field is used to separately analyze several grouping variables or several continuous dependent (not achievement) variables. See the Help manual for more information.
10. Specify the achievement scores to be used for the analysis by first clicking the **Plausible Values** field to activate it. Then, select PVCIL01–05 from the list of available variables in the left panel, and move it to the right Plausible Values field by clicking the **right arrow**(▶) button.
11. The **Weight Variable** is selected automatically by the software; TOTWGTS is selected by default because of the **Analysis Type** selected in step 3 for this analysis which uses school context data linked to student context data.
12. Specify the desired name for the output files and the folder they will be stored in by clicking the **Define/Modify** button in the **Output Files** field. The IEA IDB Analyzer also will create an R syntax file (*.R), SPSS syntax file (*.SPS), or SAS syntax file (*.SAS) of the same name and in the same folder, with the code necessary to perform the analysis. In Figure 4.19, the syntax file CIL_IP3G06A.R and the output files with the same name will be created and stored in the folder `C:\ICILS2023\Analysis`.
13. Click the **Start R** button (or Start SPSS/SAS) to create the R script (or SPSS/SAS syntax file) and open it for execution. The IEA IDB Analyzer will display a warning if it is about to overwrite an existing file in the specified folder. The R script can be executed by clicking the **Source** button or pressing **Ctrl+Alt+R** on the keyboard. In SPSS, open the **Run** menu and select the **All** menu option. In SAS, click the **Run** button (or select **Submit** in the **Run** menu).

The results as shown in the R output file are presented in Figure 4.20 with Azerbaijan and Austria as our example countries. The results are presented in the same manner as in Example 2, with countries identified in the first column and the second column describing the categories of IP3G06A.

Figure 4.20: Output for example student-level analysis with CIL achievement scores by school type

Report

Analysis for PVCIL by IDCNTRY IP3G06A

Cntry ID	Your School/Public or a private school	N of Cases	Sum of TOTWGTS	Sum of TOTWGTS (s.e.)	Percent	Percent (s.e.)	PVCIL (Mean)	PVCIL (s.e.)	Confidence Interval (95)	Std.Dev.	Std.Dev. (s.e.)	Percent Missing	Number of Variance Strata
Azerbaijan, Republic of	A public school	2949	117640	6039.00	99.23	0.77	322.63	5.33	312 to 333	99.38	3.16	0.00	73
Azerbaijan, Republic of	A private school	13	914	913.62	0.77	0.77	500.48	NaN	NaN to NaN	67.51	NaN	0.00	1
Austria	A public school	2824	62606	2767.90	91.31	2.57	503.58	3.16	497 to 510	76.48	2.12	0.00	72
Austria	A private school	302	5956	1774.71	8.69	2.57	533.19	9.31	515 to 551	65.23	6.41	0.00	13

In this example, each country's results are presented on two lines, one for each value of the Ip3G06A variable. There are fewer lines if any category does not have any observations. As shown in the two lines of results for Austria, 91.23 percent (standard error of 2.57) of the grade 8 students attended public schools and their average CIL score was 503.58 (standard error of 3.16) and 8.69 percent (standard error of 2.57) attended private schools and their average CIL score was 533.19 (standard error of 9.31).

The statistical significance of the school type differences can be determined by examining the output file named with the suffix "_sig" (CIL_IP3G06A_PVCIL_by_IP3G06A_sig in this example) provided in R data (*.Rdata) and Excel (*.xlsx) file formats. This example refers to the xlsx version, which is the same for all software, shown in Figure 4.21.

Figure 4.21: Excel "Sig" Output for analysis of average CIL by school type

CIL_IP3G06A_PVCIL_by_IP3G06A_Sig.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	IDCNTRY	dvar	groupvar	refgroup	compgroup	pct	pct_se	cpct	cpct_se	pctdiff	pctdiff_se	pctdiff_t	mnpv	mnpv_se	cmnpv	cmnpv_se	mnpvdiff	mnpvdiff_se	mnpvdiff_t	mnpvdiff_ci
2	Azerbaijan, F	PVCIL	IP3G06A	A public school	A public school	99,23	0,77	99,23	0,77	0,00	0,00	#NUM!	322,63	5,33	322,63	5,33	0,00	0,00	#NUM!	#N/A
3	Azerbaijan, F	PVCIL	IP3G06A	A public school	A private school	99,23	0,77	0,77	0,77	-98,46	1,54	-63,80	322,63	5,33	500,48	#NUM!	177,85	#NUM!	#NUM!	#N/A
4	Azerbaijan, F	PVCIL	IP3G06A	A private school	A public school	0,77	0,77	99,23	0,77	98,46	1,54	63,80	500,48	#NUM!	322,63	5,33	-177,85	#NUM!	#NUM!	#N/A
5	Azerbaijan, F	PVCIL	IP3G06A	A private school	A private school	0,77	0,77	0,77	0,77	0,00	0,00	#NUM!	500,48	#NUM!	500,48	#NUM!	0,00	#NUM!	#NUM!	#N/A
6	Austria	PVCIL	IP3G06A	A public school	A public school	91,31	2,57	91,31	2,57	0,00	0,00	#NUM!	503,58	3,16	503,58	3,16	0,00	0,00	#NUM!	#N/A
7	Austria	PVCIL	IP3G06A	A public school	A private school	91,31	2,57	8,69	2,57	-82,63	5,14	-16,09	503,58	3,16	533,19	9,31	29,61	10,18	2,91	10 to 50
8	Austria	PVCIL	IP3G06A	A private school	A public school	8,69	2,57	91,31	2,57	82,63	5,14	16,09	533,19	9,31	503,58	3,16	-29,61	10,18	-2,91	-50 to -10
9	Austria	PVCIL	IP3G06A	A private school	A private school	8,69	2,57	8,69	2,57	0,00	0,00	#NUM!	533,19	9,31	533,19	9,31	0,00	0,00	#NUM!	#N/A

For each country, the "sig" output reports the average CIL score difference between the reference group (column D) and the comparison group (column E) in column Q, labeled "mnpvdiff." Dividing this value by its standard error ("mnpvdiff_se" in column R) gives a t-statistic ("mnpvdiff_t" in column S) for evaluating whether the estimated difference is significantly different from zero. For an error level (α) of 5 percent, values greater than +1.96 (the upper critical value) or less than −1.96 (the lower critical value) indicate that the difference between the reference group (public school) average and the comparison group (private school) average is significantly different from zero. Values between −1.96 and +1.96 (the lower and upper critical values for $\alpha = 0.05$) indicate the achievement difference between the two groups is not significantly different from zero.

The t-value for the achievement difference between girls and boys in Austria is 2.91, which is above the upper critical t-values for an α level of 0.05. The (null) hypothesis was rejected, indicating the CIL score difference is statistically significant.

4.8 Trend analysis

Chapter 5 of the international report includes estimates in differences on mean CIL and CT achievement over time, i.e., across 2013, 2018, and 2023 (Fraillon, 2024). The corresponding table from the international report is shown in Table 4.5.

Table 4.5: Changes in average CIL achievement across ICILS cycles

Country	Average 2023	Average 2018	Average 2013	Difference 2023-2018	Difference 2023-2013
[1] Croatia	487 (3.9)		512 (2.9)		**-26** (6.8)
[1] Czech Republic	525 (2.1)		553 (2.1)		**-28** (5.6)
[†1] Denmark	518 (2.7)	[b,d] 553 (2.0)		**-35** (4.4)	
Finland	507 (3.6)	531 (3.0)		**-24** (5.4)	
France	498 (2.7)	499 (2.3)		-1 (4.6)	
Germany	502 (3.5)	518 (2.9)	[b] 523 (2.4)	**-16** (5.4)	**-22** (6.4)
Italy	491 (2.6)	[e] 461 (2.8)		**30** (4.7)	
[1] Kazakhstan	407 (3.1)	[d] 395 (5.4)		12 (6.8)	
[†] Korea, Republic of	540 (2.5)	542 (3.1)	536 (2.7)	-2 (4.9)	4 (6.1)
Luxembourg	494 (2.0)	482 (0.8)		**12** (3.6)	
[1] Norway (9)	502 (2.9)		[f] 537 (2.4)		**-35** (6.1)
[1] Portugal	510 (3.0)	[c,d] 516 (2.6)		-7 (4.9)	
Slovak Republic	499 (2.7)		517 (4.6)		**-19** (7.2)
[1] Slovenia	483 (2.3)		511 (2.2)		**-27** (5.8)
[†] Uruguay	447 (3.6)	450 (4.3)		-3 (6.3)	
Benchmarking participant					
[1] North Rhine-W. (Germany)	485 (4.1)	515 (2.6)		**-30** (5.7)	

Notes: Standard error appear in parentheses (). Because of rounding some results may appear inconsistent. Statistically significant differences between cycles are marked in **Bold**.
† Met guidelines for sampling participation rates only after replacement schools were included.
‡ Does not meet guideline for sampling participation rate, but achieved at least 50% overall sampling participation rate.
1 National defined population covers 90% to 95% of the national target population.
2 Country surveyed target grade in the first half of the school year.
3 National defined population covers 61% of the national target population.
b Country met guidelines for sampling paticipation rates only after replacement schools were included in the indicated cycle.
c Country nearly met guidelines for sampling participation rates after replacement schools were included in 2018.
d National defined population covered 90% to 95% of national target population in 2018.
e Country surveyed target grade in the first half of the school year in 2018.

What insights can we gain, for example, about the changes in Germany's CIL scores over time? As a participant in all three ICILS cycles, Germany provides estimated average CIL scores for 2013, 2018, and 2023, as presented in Table 4.5. The comparison reveals that the estimated mean score in 2023 decreased by 16 points compared to 2018 and by 22 points compared to 2013. However, to determine whether these differences are statistically significant, a significance test incorporating the standard error of the difference is required.

When conducting trend analyses, it is important to account for the additional error introduced by the process of equating the tests across ICILS cycles. This additional error, known as equating error, must be included in the calculation of the standard error for any differences between results from different cycles.[5] The equating errors are presented in Table 4.6.

5 The uncertainty resulting from link-item sampling is also referred to as linking error which analysts should consider when comparing the results arising out of different data collections. For more details on how the equating error is calculated see Chapter 12 of the technical report (Fraillon et al., forthcoming).

Table 4.6: Equating error for mean CIL and CT achievement estimates

Cycle	CIL	CT
2023–2018	2.839	2.569
2018–2013	3.901	

In order to estimate, if there is a difference between the mean scores between two cycles, the mean and the standard error has to be calculated for each cycle. The trend estimate is the difference between the means of 2023 and 2018. To estimate the standard error of the difference between ICILS 2023 and ICILS 2018, the two standard errors of the means need to be combined with the equating error (2.84 for CIL and 2.57 for CT) as shown in Table 4.6:

$$SE_{(2023-2018)} = \sqrt{SE_{2023}^2 + SE_{2018}^2 + EqErr_{2023-2018}^2} \tag{4.1}$$

where SE_{2023} and SE_{2018} corresponds to the standard error of the estimate in 2023 and 2018, respectively. In addition, $EqErr_{2023-2018}$ corresponds to the equating error between 2023 and 2018 of CIL or CT.

For some ICILS 2023 countries, it was also possible to compare results with the first ICILS cycle in 2013. When testing the difference of means between the first (2013) and third cycle of ICILS, the standard error of the difference should include the equating errors between the cycles ICILS 2018 and 2023 as well as between ICILS 2013 and 2018:

$$SE_{(2023-2013)} = \sqrt{SE_{2023}^2 + SE_{2013}^2 + EqErr_{2023-2018}^2 + EqErr_{2018-2013}^2} \tag{4.2}$$

For Germany, the standard error of the difference in average CIL scores is 5.4 between 2023 and 2018, and 6.4 between 2023 and 2013. These standard error estimates can be used in the formula for a significance test for independent samples, as shown for the the difference between 2023 and 2018 in Equation 4.3.

$$t_{(2023-2018)} = \frac{\hat{\theta}_{(2023-2018)}}{SE_{\hat{\theta}(2023-2018)}} \tag{4.3}$$

The difference between the estimated means for the 2023 and 2018 cycles in Germany is -16. Dividing this difference by the standard error of the difference results in a t-value of -3.0, which is below the lower critical t-value of -1.96 for an α level of 0.05. Thus, the null hypothesis is rejected, indicating that the CIL score difference in Germany between the 2023 and 2018 ICILS cycles is statistically significant. The steps for calculating the t-value for the CIL score difference between 2023 and 2013 are identical.

Please see also Chapter 13 in the ICILS 2023 technical report (Fraillon et al., forthcoming), which include more information on the reporting of differences.

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IEA's International Computer and Information Literacy Study (ICILS) 2023 is designed to respond to a question of critical interest today: How well are students prepared for study, work, and life in a digital world?

The study measures international differences in students' computer and information literacy (CIL): their ability to use computers to investigate, create, participate, and communicate in order to participate effectively at home, at school, in the workplace, and in the community. Participating countries also have an option for their students to complete an assessment of computational thinking (CT).

The ICILS 2023 user guide describes the content and format of the data in the ICILS 2023 international database. It provides a comprehensive overview of how to work with IEA's International Database (IDB) Analyzer software and has a strong practical, hands-on focus. The ICILS 2023 user guide is accompanied by three supplements: the international versions of all questionnaires; an overview of national adaptations to the national versions of the ICILS 2023 international questionnaires; and a comprehensive catalogue of the derived variables used in the ICILS 2023 international report.

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